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Applying Training System Estimation Models to Army Training Volume II: An Annotated Bibliography 1970-1990

Frederick A. Muckler
Dorothy L. Finley

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Muckler, F. A.; Finley, D. L.

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A review and analysis of the literature about training system models and methods during the last 20 years was conducted. Thirty-six training system estimation models were identified. The models were evaluated with respect to the adequacy of their documentation and their ability to predict cost effectiveness, training efficiency, training effectiveness, and appropriate media selection. The purpose was to review the history and state of the art of such models and to identify their strengths and deficiencies. The goal was to see to what extent these models could be useful for enhancing future Army training system resource estimation early in the development of a materiel system.

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FOREWORD

One long-range research goal of the U.S. Army Research Institute, and subsequently the Human Research and Engineering Directorate of the U.S. Army Research Laboratory, is to develop methods for estimating the resources required to develop and implement the training system to support a new materiel system. The objective is to influence the design of that materiel system early in its development program by showing the impact of alternate materiel system designs on training development and implementation costs. As an initial step in the development of such methods, a broad-based review of the literature was conducted to establish the state of the art and to identify what models and methods currently exist that might provide useful inputs to the program. Given the breadth of the search, this report has been assembled in the hope that others might find the abstracts under one or more topics germane to their concerns.

The reviewed literature is organized under the topic area headings of training system models; training requirements determination, and design and development methods; prediction and evaluation of student and media performance effectiveness; training media; factors influencing outcomes; costing and resourcing; and miscellaneous. An analysis of this literature is presented in Volume I of this report.

This research has been performed under the auspices of Research Task 1209, Soldier-Equipment Considerations in Military Occupational Specialty (MOS) Design. Work under that task is focusing on the development of methods to optimize the clusters of tasks (i.e., task structure, assigned to MOSs when changes occur in doctrine or as a function of force modernization). One of the major impacts of changes in MOS task structure, and one that must be accounted for, is on the design of the training system supporting the MOSs. The research of MOS restructuring and this review of the literature will provide inputs to the long-range goal of developing training system resource estimation methods that will affect materiel system design choices.

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APPLYING TRAINING SYSTEM ESTIMATION MODELS TO ARMY TRAINING: VOLUME II. AN ANNOTATED BIBLIOGRAPHY 1970-1990

Frederick A. Muckler
Dorothy L. Finley

May 1994

The Systems Research Laboratory of the U.S. Army Research Institute (ARI), referenced in this report, has been reorganized as part of the Human Research and Engineering Directorate of the U.S. Army Research Laboratory, effective 1 October 1992. The program and facility described here were completed before the organizational change.

APPROVED: Robin L Keesee
ROBIN L. KEESEE
Executive, Human Research & Engineering Directorate

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U.S. ARMY RESEARCH LABORATORY

Aberdeen Proving Ground, Maryland

CONTENTS

EXECUTIVE SUMMARY

RESEARCH REQUIREMENTS

The design of a prime materiel system from the standpoint of its operability and maintainability on the part of the soldier largely determines the manpower, personnel, and training (MPT) resource requirements needed to support the system. It is one of the tenets of the manpower and personnel integration (MANPRINT) program that, to the extent that the MPT resource requirements and reasonableness thereof can be estimated early in the prime system's development program, the greater the likelihood that prime system designs that are costly to support and noneffective will be avoided. That is, alternate system designs will be considered that are less MPT resource intensive.

A long-range goal of the U.S. Army Research Institute, and subsequently the Human Research and Engineering Directorate of the U.S. Army Research Laboratory, is to develop methods for estimating the resources required to develop and implement the training system to support a new materiel system design early in that system's development. A necessary first step was to review the literature to determine the state of the art and to identify what models and methods exist that might provide useful inputs to the program.

PROCEDURE

The definition of "estimation" used in the search for documents was a broad-based one. An attempt was made to uncover any ideas that bore directly on the prediction, estimation, or evaluation of the design, cost, performance, or effectiveness of a training system. Likewise, there was no attempt to restrict the search to training "systems" per se. While we feel that the training "system" that supports a materiel end item may encompass many subsystems and elements, many authors do not use the term in such an all-encompassing manner. Many view, for example, a single training device, intelligent tutoring system, or other medium as a training system, even though these media may play only a small part in the overall training programs, necessary facilities, and so forth that support a materiel system.

The primary sources reviewed in the literature search include the proceedings of the annual Human Factors Society conferences, Psychological Abstracts, and the authors' personal libraries. In addition, some documents were obtained from the National Technical Information Center after a search was performed under such terms as training systems and training resource estimation.

FINDINGS

One hundred seventy-five reports were reviewed. The abstracts fell into several topic areas and were organized accordingly. The major topic areas include training system models; training requirements determination, and design and development methods; prediction and evaluation of student and media performance effectiveness; training media; factors influencing outcomes; costing and resourcing; and miscellaneous. Several documents fell into more than one category. When this occurred, the abstracts have been presented under the first topic heading and then cross referenced under the subsequent topic headings.

USE OF FINDINGS

This annotated bibliography has been assembled in the hope that others might find the abstracts under one or more topics germane to and useful for addressing their concerns. The documents were analyzed and formed the basis for Volume I. Therein, the state of the art with regard to such models is described, and research issues are identified.

APPLYING TRAINING SYSTEM ESTIMATION MODELS TO ARMY TRAINING: VOLUME II. AN ANNOTATED BIBLIOGRAPHY 1970-1990

INTRODUCTION

Purpose

One long-range research goal of the U.S. Army Research Institute, and subsequently the Human Research and Engineering Directorate of the U.S. Army Research Laboratory, is to develop methods for estimating the resources required to develop and implement the training system required to support a new materiel system. The objective is to influence the design of that materiel system early in its development program by showing the impact of alternate materiel system designs on training development and implementation costs. As an initial step in the development of such methods, a review of the literature was conducted to establish the state of the art and to identify what models and methods currently exist that might provide useful inputs to the program. This report presents abstracts of the reviewed literature. The analysis of this literature is presented in Volume I of this report.

Even though the ultimate goal of this program is focused on methods for resource estimation, the definition of training system "estimation" used in this literature search was purposely a much broader one. An attempt was made to uncover any ideas that bore directly on the estimation or evaluation of the design, cost, performance, or effectiveness of a training system. Likewise, there was no attempt to restrict the search to training "systems" per se. While we feel that the training "system" that supports a materiel end item may encompass many subsystems and elements, many authors do not use the term in such an all-encompassing manner. Many view, for example, a training device, intelligent tutoring system, or other medium as a training system, even though these media may play only a small part in the overall training programs, necessary facilities, and so forth that support a materiel system.

Given the breadth of the search, this report has been assembled in the hope that others might find the abstracts under one or more topics germane to their concerns. The primary sources reviewed in the literature search include the proceedings of the annual Human Factors Society conferences, Psychological Abstracts, and the authors' personal libraries. In addition, some documents were obtained from the National Technical Information Center after a search was performed under such terms as training systems and training resource estimation.

Organization of the Report

The abstracts are organized into major topic areas with, in some cases, subheadings. The topics include

- Training system models: concepts and simulations of what training systems are comprised of and how they operate;

- Training requirements determination, and design and development methods: materials that bear on the development of training programs and systems, including general analysis methods; alternate strategies; and methods specific to crew and team training and to leader and instructor training;

- **Prediction and evaluation of student and media performance effectiveness:** methods and findings that relate to the (1) *a priori* prediction of whether groups of students and specific media will be successful in training and (2) evaluation of whether they were successful in training;

- **Training media:** considerations and demonstrations regarding what features might be advantageous to include in a training medium; methods for selecting among media choices; and information specific to training devices and to computer-based training and artificial intelligence;

- **Factors influencing outcomes:** research concerning various factors affecting training outcomes that did not fall into the previous categories (e.g., instructor work load, individual differences, cooperative learning);

- **Costing and resourcing:** descriptions of models of, methods for, and considerations regarding the determination of costs to develop and operate training programs and media; and

- **Miscellaneous:** materials that were related to the general issue but did not fall easily into any of the previous categories. Several reports attempt to integrate subject areas related to training.

Several documents fell into more than one category. When this was the case, the abstract appears in the first category under which it falls, and reference is made to it in the appropriate subsequent categories, using their item numbers. The abstracts are not presented alphabetically by author names. When the abstracts are reviewed, date was the most meaningful sequencing. Whole areas of endeavor and individual programs have flourished and evolved during the years. The first three topic areas, for example, have evolved in terms of more and more detailed procedures in general with tailor-made procedures coming into being for some specific types of training (e.g., development methods for training devices and embedded training). In the area of training media, the evolution into increasingly interactive and intelligent media is apparent. It is only by presenting the abstracts sequentially by date that these changes in the state of the art become apparent.

For those readers who have a need or desire to search for a particular author, all authors are listed in the appendix. They are listed alphabetically and referenced to the text.

TRAINING SYSTEM MODELS

096 Kaufman, R.A., Corrigan, R.E., & Nunnelly, C.L. (1966). The instructional system approach to training. Human Factors, 8(2), 157-162.

A generalized model for an Instructional System is offered, as well as a model for such a system for use in preparing training and training materials for the U.S. Air Force. The rationale for a systematic approach to training is presented along with a discussion of a relationship between an Instructional System and Programmed Instruction.

015 Brock, J.F. (1978). Maintenance training and simulation: design processes and evaluation criteria. Proceedings of the Human Factors Society-22nd Annual Meeting, 260-266.

There is general agreement among instructional designers that training people to maintain complex systems has unique characteristics not found in other training endeavors. These unique characteristics stem from the kind of cognitive and psychophysical tasks which must be performed by the system maintainer. This paper discusses the uniqueness required of maintenance training systems and sets out a model for designing such systems. Examples from basic and advanced maintenance training systems are presented with a discussion of how and why particular instructional strategies were selected. Alternative strategy selection techniques are discussed.

A review of current simulation techniques for training maintenance tasks is presented in the context of general design considerations for maintenance training. Computer-based systems are compared along dimensions of cost, reliability, modifiability, hands-on capability, safety, and student performance data.

A concurrent problem in maintenance training is the determination of whether a training system is, in fact, functioning efficiently and effectively. Efficiency and effectiveness are defined and a model for measuring each is proposed. A section of the paper addresses the economic issues in the evaluation of training.

045 Finley, D.L., Strasel, H.C., Bloom, R.L., & Oates, J.F. (1982). An analytic process method for defining appropriate measures of systems' performance and effectiveness. Proceedings of the Human Factors Society-26th Annual Meeting, 835-839.

A definition of what constitutes a training system, and a systematic analytic process for better defining necessary and sufficient measures of training and other systems are presented. The research to develop the definition and process was accomplished within the context of a relatively complex Army man-machine system.

114 Matlick, R.K., Swezy, R.W., & Epstein, K.I. (1982). Alternative models for individualized armor training: I. Interim report: Review and analysis of the literature. Catalog of Selected Documents in Psychology, 12(4), 49.

163 Sticha, P.J., Knerr C.M., & Goldberg, S.L. (1984). Application of simulation and modeling to army training management. Proceedings of the Human Factors Society- 28th Annual Meeting, 1023-1027.

Simulation models to aid the training manager may be developed at three levels of increasing generality: task performance models, task training models, and training system models. The more general models encompass more variables, and hence, are more useful to the training manager. The bulk of research in this area has concentrated on task performance models, and within this framework, has studied skill retention. The findings of this research must be integrated with system cost and utility information to produce a training system model. Development of such a model can provide an essential set of tools to be incorporated into a decision support system for training management.

004 Aldrich, R.E., Strasel, H.C., & Ditzian, J.L. (1986). The Army unit training model and guidelines for the integration of Embedded Training (ET). Proceedings of the Human Factors Society- 30th Annual Meeting, 1019-1023.

Embedded Training (ET) is a new training alternative for individual and collective sustainment training in Army systems at the unit level. This paper outlines the existing Army Unit Training Model, ET integration requirements, guidelines for the integration of ET into the existing components of the Army Unit Training Model and the creation of a new ET specific component.

148 Shapiro, R.G., Bloom, R.L., & Oates, J.F. (1986). The computer-aided analytic process model: Operations handbook for the analytic process model demonstration package (ARI Research Note 86-06). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

The computer-aided APM demonstration provides the analyst with the opportunity to perform a thorough analysis of a system, while the computer keeps track of the analysis, and insures that the analyst examines the parts of the data base which are of interest. This is, however, a demonstration package which can only process small data bases. Because the package is implemented on an Apple II Plus, processing is relatively slow. An explanation of the APM listings of data sets derived using the APM and recommendations for further development of the APM model appear in the companion volume - "The Analytic Process Model for System Design and Measurement: A Computer-Aided Tool for Analyzing Training Systems and Other Human-Machine Systems."

149 Shapiro, R.G. (1986). The computer-aided analytic process model: Appendix to the Operations Handbook for the APM demonstration package (ARI Research Note 86-07). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

The computer-aided APM demonstration package provides the analyst with the opportunity to perform a thorough analysis of a system while the computer keeps track of the analysis and insures that the analyst examines the parts of the data base which are of interest. This is, however, a demonstration package which can only process small data bases. Because the package is implemented on an Apple II Plus, processing is relatively slow. An explanation of the APM, listings of the data sets derived using the APM and recommendations for further development of the APM appear in the companion volume- "The Analytic Process Model for System Design and Measurement: A Computer-Aided Tool for Analyzing Training Systems and Other Human-Machine Systems." A separate companion volume- "The Computer-Aided Analytic Process Model:

Operations Handbook for the APM Demonstration Package" is also available under separate cover. The present volume, which is an Appendix to the Operations Handbook, contains the actual PASCAL computer code listings. Disks containing this code and the data bases in machine-readable format are also available.

141 Roth, J.T. (1988). Implementing Embedded Training (ET): Volume 3 of 10: The Role of ET in the Training System Concept (Research Product No. 88-13). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

This product provides a step-by-step procedure for developing a training system concept very early in the materiel acquisition process. The training system concept produced outlines appropriate roles for Embedded Training and Stand-alone Training Devices in supporting hands-on training for a materiel system, with respect to nine specific training needs or situations.

082 Hinton, W.M., Braby, R., Feuge, R.L., Stults, A.H., Evans, S.M., Gibson, M.R., & Zaldo, W.T. (1990). A design architecture for an integrated training system decision support system. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

This report presents the results of a systems engineering analysis of the training development process required to produce an Integrated Training System (ITS) for a New Weapons System (NWS). This work was performed in response to the findings of the 1985 Army Science Board and the latest Army Aviation Mission Area Analysis, which suggest that Army training development for NWS can be improved by using a "top-down" approach to training system development starting very early in the NWS acquisition process. The report contains the design architecture for an Army ITS Decision Support System (DSS), portrayed in IDEF diagrams, plus supporting data on potential users of the system, embedded training, ITS data sources, and a set of training system design elements. The architecture spans the full cycle of NWS development from Milestone 0 through fielding and long term maintenance. It integrates all aspects of ITS development within and across Military Occupational Specialties, such as individual, collective, and combined arms training and institutional, unit, and distributed training. The architecture provides the basis for the development of the functional specifications for the DSS. Specific intervention points are identified to provide the focus for future efforts to develop individual methods and procedures which are compatible with the overall model.

Analysis Methods

049 Fischl, M.A., & Siegel, A.L. (1970). Skill and knowledge requirements for the AN/BQR-2 DIMUS. (APS Technical Report). Wayne, PA: Applied Psychological Services, Inc.

Skill and knowledge requirements were determined for use in developing personnel and training requirements studies and to provide a base line for use by Navy sponsored definition evaluation panels. Multidimensional scaling analysis was employed to obtain operation and maintenance skills and knowledges for two competing DIMUS systems. The DIMUS system is a new digital multibeam steering sonar system. The DIMUS skill and knowledge requirements were represented by 8 factors: the maintenance skill and knowledge requirements by 5 factors. (sic)

085 Hoyt, W.G. (1972). System engineering of training for a new major system: Applied, computerized, and utilized. Proceedings of the Human Factors Society - 16th Annual Meeting.

The subject of this paper is a unique application of system engineering of training for a new system development. It is a report of what has been accomplished, and it can serve as a model for conducting similar projects. Of special interest in this report are: the approach, which is different because we have been dealing with a new system not yet operational and not much is contained in the literature about new systems; but also new solutions have been found to old problems and these solutions are applicable to both old and new systems. The solutions result from good system analysis; adherence to the principle of letting the data drive the methodology rather than the methodology driving the data; the principle of developing a sufficient base within each step in the systems engineering process before making decisions further down the line, e.g., establishing the training requirements first, prior to the consideration of constraints which may be imposed; and the principle of adequate record keeping and organization of data. The latter makes possible an easy, cost-effective revision, evaluation and reporting process. This facilitates understanding, evaluation, and use of the results and consequent user acceptance. Cost-effective computer capability is used throughout the system engineering process to provide the visibility and manipulation necessary for the communication, control, and reporting process.

072 Hansen, D.H. (1973). The analysis and development of an adaptive instructional model(s) for individualized technical training: Phase I (U.S. AFHRL Technical Report No. 72-50(1)). Brooks Air Force Base, TX: U.S. Air Force Human Resources Laboratory.

Describes the purpose and function of Adaptive Instructional Models (AIM), a series of computerized instructional tasks for individual training (e.g., drill-and-practice, concept acquisition, complex tutorial, and algorithmic regression models). Seven AIMs are analyzed and recommendations for their application in Air Force technical training courses are presented.

134 Rigney, J.W., Morrison, D.K., & Williams, L.A. (1974). A guide for the application of performance-structure oriented CAI in naval training: A working paper (NAVTRAEQUIPCEN Technical Report No. 73-C-0065-1). Orlando, FL: U.S. Navy Training Equipment Center.

Describes considerations and procedures for applying Performance-Structure Oriented Computer-Assisted Instruction (CAI) in naval training in terms of a general diagram of the necessary elements in a CAI system. The developmental steps, from job task-structure analyses to computer programs are described.

154 Siegel, A.L., Federman, P.J., & Sellman, W.S. (1974). A survey of student measurement and course evaluation procedures within the Air Training Command. Lowry Air Force Base, CO: Technical Training Division.

Surveyed the reactions of training-evaluation, student-measurement, and training-manager-instructor personnel to the U.S. Air Force Instructional System Development (ISD) system. Favorable user reactions, problems associated with ISD procedures, and recommendations for ISD program improvements are presented.

012 Braby, R., Henry, J.M., Parrish, W.F., & Swope, W.M. (1975). A technique for choosing cost-effective instructional delivery systems (TAEG Report No. 16). Orlando, FL: Training Analysis and Evaluation Group.

Describes a technique for choosing cost-effective instructional delivery systems for proposed training programs-the Training Effectiveness, Cost Effectiveness Prediction (TECEP) technique. It provides an orderly approach for the skilled training system designer to use in making delivery system choices during the conceptual design phase. A 3-step procedure is described in which training objectives are classified and organized into groups, appropriate learning strategies are defined for each group, media capable of supporting these strategies are identified, and the costs of alternative forms of training are projected. With this information, optimum delivery system choices can be made. A list of 12 types of learning algorithms and the class of learning objectives each supports, separate tables for choosing instructional delivery systems for each algorithm, and a cost model for comparing the value of resources required by alternative delivery systems are presented. A Fortran IV program listing of the cost model is included.

013 Branson, R.K., Rayner, G.T., Cox, J.L., Furman, J.P., King, F.J. (1975). Interservice procedures for instructional systems development. Executive summary and model. Tallahassee, FL: Florida State University, Tallahassee Center for Educational Technology.

The report is a five volume set of procedures developed for the preparation of a curriculum when interservice training is called for. The procedures address five major phases, which are: Analyze, Design, Develop, Implement, and Control. The procedures begin with a methodology for conducting a job analysis for the curriculum subject area for which the instruction is to be developed and then to go through 18 additional steps suitable for the empirical development of interservice training. This volume contains a summary and model.

Other common citation for the above document:

Department of the Army (1975). Instructional systems development (TRADOC Pamphlet 350-30, five volumes). Fort Monroe, VA: U.S. Army Training and Doctrine Command.

030 Cream, B.W., Eggemeier, F.T., & Klein, G.A. (1975). Behavioral data in the design of aircrew training devices. Proceedings of the Human Factors Society - 19th Annual Meeting.

Attention has recently been focused on the use of ISD behavioral data for specifying aircrew training requirements. However, behavioral data are not sufficient for the actual specification of design of equipment, which frequently represents the major dollar investment for training programs. The paper presents a methodology for designing training equipment. This methodology in some ways goes beyond the collection of behavioral data, and in other ways avoids the weakness of the behavioral data approach. The emphasis is on ensuring that device fidelity requirements are specifically correlated with training requirements. Four critical areas are addressed: (1) acquisition of behavioral data; (2) determination of training capabilities; (3) performance measurement; and (4) special requirements for crew coordination training.

167 Sugarman, R.C., Johnson, S.L., Hinton, W.M., & Buckenmaier, C.C. (1975). SAT revisited- a critical post-examination of the systems approach to training. Proceedings of the Human Factors Society-19th Annual Meeting.

A unique application of the Systems Approach to Training (SAT) was carried out for the design of the B-1 aircrew instructional system. A preliminary report was presented at the 1975 Human Factors Society Meeting by Johnson, et al., (1974) and Sugarman, et al., (1974). Based on the additional experience, this presentation will share with the training community a look at some of the strengths and weaknesses of the SAT process. The particular application provided a harsh test of the process since the B-1 air vehicle is still in the developmental stages. This resulted in many opportunities to be faced with missing or incomplete data whose criticality to the analysis became more than apparent. The general state-of-knowledge within Instructional System Development (ISD) itself is incomplete, which also became apparent when applying a highly structured (i.e., internally consistent and documented) SAT process. The major strength of the SAT process is the capability it provides for the justification of many decisions that were hitherto prone to hand-waving. This particular strength comes from the internal documentation for each decision process which is an important feature of SAT. The adequacy of the assumptions underlying the decision processes then becomes subject to scrutiny. The power of the documentation is enhanced by the use of computer aids in data management and economic analysis which facilitate the documentation. Within the present paper, problem areas which weaken the SAT process are also discussed. These include the data bases for the task analysis and economic/policy data, the media selection process, and the development of instructional strategies.

001 Aagard, J.A., & Braby, R. (1976). Learning guidelines and algorithms for types of training objectives (TAEG Report No. 23). Orlando, FL: Training Analysis & Evaluation Group.

Presents training strategies for 11 common classes of objectives: recalling bodies of knowledge, using verbal information, rule learning and using, decision making, detecting, classifying, and identifying symbols, voice communicating, recalling procedures and positioning movements, steering and guiding and continuous movement, and performing gross motor skills. The strategy for each class of instructional objectives is made up of 3 parts. The first is a definition of the class and a description of the uniqueness of each class. The second is a set of learning guidelines, consisting of a series of statements which prescribe specific learning elements to be built into the design of a training system. These guidelines are based mostly on learning theory and on practical experience and represent information available for prescribing general solutions for a class of training problems. The third part is a learning algorithm, expressed as a flow chart of a sequence of learning events. It represents a logical arrangement of events called for in the guidelines. These guidelines and algorithms may be used by training system designers as guidance in specifying learning events and activities, selecting instructional delivery vehicles, designing instructional materials, evaluating existing instructional materials, and recording field experience for use in improving guidelines and algorithms.

038 Duffy, L.R., Miller, R.B., & Staley, J.D. (1977). Design of training systems: Computerization of the educational technology assessment model (ETAM) (Training Analysis and Evaluation Group Report No. 40(1)). Orlando, FL: Training Analysis and Evaluation Group.

The first volume of a two-volume report summarizes the analysis, design, and development activities associated with the Educational Technology Assessment Model (ETAM). It contains relevant background information and results of prior studies leading to the finalized ETAM procedures and computerized routines. A comparison of the manual and automated approach is included, and data base structures and ETAM program flow are described. The second volume (see PA, Vol 59:11358) contains the 344-page appendix.

039 Duffy, L.R., Miller, R.B., & Staley, J.D. (1977). Design of training systems: Computerization of the educational technology assessment model. (ETAM): II (Training Analysis and Evaluation Group (TAEG) Report, 40(2)). Orlando, FL: Training Analysis and Evaluation Group.

The second volume of a 2-volume report (for the first volume, see PA, Vol 59:13361) on the Educational Technology Assessment Model (ETAM) contains the appendix which includes the results of a study on the indexing of innovations and the assignment of taxonomic descriptors to courses, job/tasks, and instructional vehicles. The appendix also includes program documentation on the ETAM Range-of-Effect, 4 pages of bibliographic references, and additional information supporting the ETAM design.

011 Booher, H.R. (1978). Job performance aiding systems technology selection algorithm. Proceedings of the Human Factors Society-22nd Annual Meeting, 158-162.

A nine-step selection algorithm is described which relates personnel aptitude, experience, task and equipment complexity, and degree of proceduralization in a decision chain for choosing optimum combinations of job performance aids

(JPAs) and training technologies. The algorithm has been useful in (1) identifying JPA research and technology gaps, (2) identifying candidate JPA systems for Navy personnel, maintenance and training trade-off analyses, and (3) in selecting specific JPA systems for test and evaluation in the Navy Performance Aids Test and Evaluation project. The algorithm development has also included efforts to identify and evaluate specifications and guidelines available for JPA procurement/implementation and to highlight areas where information should be gathered for an integrated JPA/training/maintenance/personnel user handbook.

055 Gibbons, A.S. & Hughes, J.A. (1978). A method of deriving hierarchies of instructional objectives. Proceedings of the Human Factors Society-22nd Annual Meeting, 88-90.

A method is outlined for the development of hierarchies of instructional objectives to be used in instructional development or training. The method proposed increases the specificity normally encountered for hierarchy development and allows participation of non-scientist level workers in the generation of analyses with anticipated logical qualities. A system of deriving hierarchy patterns growing out of the application of the analysis is also described which assists the development and simplifies the analysis process.

143 Sauer, D.W., & Askren, W.B. (1978). Validation of an expert estimate technique for prediction manpower, maintenance, and training requirements for proposed Air Force systems (AFHRL-TR-78-19). Brooks Air Force Base, TX: U.S. Air Force Human Resources Laboratory.

The objectives were to determine the validity of an expert estimate technique for predicting manpower, maintenance, and training requirements for equipment in the early stages of design, and to develop a guide for implementing the technique. Sixty Air Force technicians from two avionics AFSCs participated as expert estimators. Twenty of these technicians were also qualified avionics instructors. The 60 technicians made estimates of manpower, maintenance, and training requirements using only an engineering description of an operational avionics component. The description contained information available during the early design stages of the component. The accuracy of the estimates was determined by comparing them with manpower, maintenance, and training data associated with the operational equipment. The results indicate that maintenance task time, crew size, skill level, career field, and task difficulty can be estimated with a satisfactory degree of accuracy. Training times were greatly overestimated. The estimates of required training facilities/equipment and the impact of design features on maintenance were nonconclusive. The results also indicate that ten technicians with skill level 5 and with system experience on equipment similar to the proposed equipment will produce acceptable estimates. A prototype guide for using the technique was prepared.

057 Gilbert, A.C., Waldkoetter, R.O., Raney, J.L., & Hawkins, H.H. (1980). Efficacy of a training priorities model in an Army environment. Catalog of Selected Documents in Psychology, 10, 69-70.

108 Lenzycki, H.P., & Finley, D.L. (1980). How to determine training device requirements and characteristics: A handbook for training developers (ARI Research Product 80-25). Alexandria, VA: U.S. Army Research Institute for the Béhavioral and Social Sciences.

This handbook was prepared for use by U.S. Army training developers and others accountable for determining requirements for and characteristics of training devices to support hardware fielding. It contains a description of a methodology for performing the front-end analysis needed to determine what tasks have to be trained (training requirements); the need for a training device(s) as a medium for developing required task skills (training device requirements); and the characteristics that the device should possess in order to promote effective learning (training device characteristics). The handbook supplements and extends the contents of ISD Pamphlet 350-30 in that it: (1) further details the process for developing task descriptions and acquiring other job information needed to assess the demands imposed on the operator by the equipment, operational environment, other crew members and interactive systems; (2) provides additional criteria and rating scales for use in the task analysis process; (3) allows for specific identification of requirements for training equipment (actual or device) as opposed to the ISD process which leads to the identification and selection of generic training media alternatives; and (4) leads to the identification of specific characteristics of devices needed to provide the essential skills training.

174 Vineberg, R., & Joyner, J.N. (1980). Instructional system development (ISD) in the armed services: Methodology and application (ARI: HumRRO-TR-80-1). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

The study examined Instructional System Development (ISD) methodologies and practices in the Army, Navy, Marine Corps, and Air Force during Aug. 1977-Mar. 1979. Findings are based on (1) analysis of the primary guidance documents used in the Armed Services for conducting ISD, (2) questionnaire survey of 209 units, agencies and schools where training is developed in the Services, and (3) detailed interview of training developers at 33 organizations to determine how 57 courses were designed. Major findings are that ISD is not being used either to optimize total system effectiveness or to maximize training efficiency.

The iterative and derivative character of the methodology can insure that training will be relevant to job requirements if its procedures are faithfully carried out. In practice, however, many of the components of ISD are omitted and the close connection between components to make the process truly derivative is not maintained. Thus the potential of ISD to insure that training meets job requirements is not being realized. The conception of ISD that is most adequately represented in current applications of ISD is as the use of specific elements of modern training technology, i.e., job analysis, self-paced instruction. Considerable evidence leads to the conclusion that although the generation of the products of ISD can be mandated, the ISD process itself cannot. Training is both developed and evaluated within the training subsystem, whereas the consequences of training occur in operational units. It is recommended that operational commands be given a larger role in identifying job requirements, establishing training requirements, and evaluating the performance of training graduates. The report also contains findings and recommendations for 19 specific steps of the ISD process.

077 Hawley, J.K., & Dawdy, E.D. (1981). Training device operation readiness assessment capability (DORAC): Feasibility and utility (Army Research Institute: Applied Sciences Associates Final Report). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

This report presents the results of an investigation of the feasibility and utility of implementing the Training Device Operational Readiness Assessment Capability (DORAC) concept throughout the Army. The investigation addresses three separate aspects of feasibility.

Another aspect of DORAC concept feasibility concerns the ability to select the most cost-effective proficiency assessment capability from among a range of alternatives. To this end, Cost and Information Effectiveness Analysis (CIEA) methodology based on multi-attribute utility measurement (MAUM) was developed and is presented in a companion report. In this report, the MAUM-CIEA methodology is demonstrated using a set of hypothetical DORACs for the M16A1 rifle.

The final section of the report integrates the feasibility results into a series of recommendations for optimizing the payoff from a DORAC, and suggests a series of steps for further investigation of the concept and related technologies.

127 Pieper, W.J., Guard, N.R., Michael, W.T., & Kordak, R.S. (1981). Training developers decision aid for optimizing performance-based training in machine ascendant MOS. Catalog of Selected Documents in Psychology, 11, 87.

130 Reece, H.F. (1982). Computers, learning styles and instructional materials- are they related? Academic Therapy, 18(2), 157-161.

Describes a microcomputer-based system for organizing instructional materials in a school system so that the teacher can select appropriate materials for special students. Steps in designing the system include reviewing resource material in terms of educational goals, grade levels, and instructional strategies; establishing a data file; designing a program that allows teachers and other staff to perform custom computer searches of the database to see what material in the system are appropriate for a given student; and evaluating the results.

162 Spears, W.D. (1983). Processes of skill performance: A foundation for the design and use of training equipment (NAVTRAEQUIPCEN Technical Report 78-C-0113-4). Orlando, FL: U.S. Navy Training Equipment Center.

Discusses analysis of skill performance as a basis for the design of low-cost training devices for use in the military. Cognitive motor skills are analyzed in terms of the processing of information. Cognitive processes involved in motor skills and information processing include task recognition; task comprehension; goal setting; planning performance; initiation, monitoring, and regulation of performance, stimulus encoding and elaboration, attentional processes, retention and retrieval of information; hierarchical schemata for discrimination and generalization; motivation, and skill integration and automation. For motor skills, emphasis is placed on structural characteristics of movements, temporal characteristics of movements, signal discrimination and generalizations, roles of sensory modes and their interactions, and patterns of skill integration. Empirically based concepts provide an operational means of manipulating variables during training, and examples are

presented of methods for empirically assessing roles of various processes. It is concluded that analyses could be extrapolated to general training technology and to the design of training devices.

007 Ball, F.M. (1984). The instructional systems development model and systems engineering. Proceedings of the Human Factors Society-28th Annual Meeting, 845-849.

Two implicit perspectives governing the organization of human performance have evolved within the training community, leading to two different approaches to the systematic development of performance-based training. These are identified here as the Instructional Systems Development (ISD) approach, and the Systems Engineering approach. Both employ similar procedures with the exception that the ISD approach relies on an initial job-oriented analysis; the Systems Engineering approach relies on a functional systems analysis. This difference affects the scope and organization of the data. Resulting training programs and materials are more suited to some applications than to others. This paper presents a conceptual framework illustrating the relationship and argues that the two approaches are theoretically equivalent. Within this framework practical training development implications, problems, and benefits are discussed.

078 Hawley, J.K. (1984). Some considerations in the design and implementation of a training device performance assessment capability. Proceedings of the Human Factors Society-28th Annual Meeting, 201-205.

In an era of increasing system complexity and resource constraints, live-fire exercises on a scale necessary to insure personnel proficiency are not feasible for many weapons systems. A partial solution to the problem of insufficient performance evaluation involves the use of training devices in lieu of operational equipment in the conduct of evaluation exercises. A trainer that has been extended to include an embedded performance evaluation capability is referred to as a training device performance assessment capability (DPAC). The present paper presents a series of guidelines for the design and development of DPACs. The guidelines were prepared on the basis of background research and actual experience in developing a DPAC for the Patriot air defense missile system. Because of their association with an actual developmental effort, the guidelines have considerable practical utility for DPAC design and implementation. A number of issues important for the full realization of DPAC potential also are discussed.

091 Johnson, S.L. (1985). Using mathematical models of the learning curve in training system design. Proceedings of the Human Factors Society- 29th Annual Meeting.

This paper reviews and synthesizes some of the literature on the mathematical modeling of the learning curve that has been developed by many diverse technical disciplines. These disciplines include the behavioral sciences, manufacturing engineering, and accounting. The paper discusses the relationships among the models and the potential uses of the models in the design, development, and control of training systems.

099 Kemmer-Richardson, S., Lamos, J.P., & West, A.S. (1985). Computer-assisted instruction: Decision handbook (U.S. AFHRL Tech Rpt 84-46). Brooks Air Force Base, TX: U.S. Air Force Human Resources Laboratory.

Notes that this handbook is meant to serve as a resource and reference guide for U.S. Air Force instructional managers who are considering the adoption or expansion of computer-assisted instruction (CAI) at some future time and also as a decision aid for an instructional manager currently involved in the CAI decision process. The use of the handbook is considered to be appropriate for considering the implementation of CAI in a new course or in an existing course. The workbook portion of the handbook presents specific tools, in the form of worksheets, for evaluating the need for CAI, for identifying configurations most closely matched to instructional needs and practices, and for estimating the feasibility of initiating CAI implementation.

123 Myers, G.L., & Fisk, A.D. (1985). Toward a skill based training technology: review, evaluation, and application of automatic/controlled processing training guidelines. Proceedings of the Human Factors Society-29th Annual Meeting.

In the present paper it is argued that there are two major purposes of instruction for skill acquisition. The first is to insure that the consistent components of the skill are identified by the trainee. The second purpose is to provide many correct executions of (or exposures to) these consistent components. A brief review of the laboratory research supporting the above statements is provided. The concept of consistent component training is described, and a preliminary application of the non-laboratory approach is outlined. Guidelines are discussed for specifying consistent trainable components of a skill or task.

010 Bloom, R.S., & Yanko, D.M. (1986). Use of job task analysis to determine training requirements. Proceedings of the Human Factors Society, 1448-1451.

This paper contains a discussion of how two job task/human performance analysis systems have been used in the nuclear utility industry to a) determine training program curriculum and content requirements, and b) provide data for management decisions regarding training system development. This is a presentation of the methods used in a performance analysis of a variety of workers, the products created, and to what end those products were used. The paper is a pragmatic application which training systems personnel can use in their work situations to develop training programs grounded in data generated by job task/human performance analysis.

118 Montague, W.E. (1986). Technical training and Instructional Systems Development: Can a cognitive model help? Advances in Reading/Language Research, 4, 119-138.

Discusses deficiencies in the Navy's approach to Instructional Systems Development (ISD) for technical training and suggests improvements. Navy training is not systematically organized, focuses on preparatory training, is based toward text instruction and against contextual relations, and has a weak link between jobs and training. While the ISD process was developed to strengthen the connection between training and the work environment and to permit management by personnel untrained in teaching and related specialties, it has not worked well. The overly simple behavioral psychoeducational model

adopted by ISD fails to incorporate recent developments in cognitive research on mental representations and analytic procedures. A practical mechanism for improvement is to automate as much of the ISD process as possible, in a way that is unobtrusive to users and provides them with the capabilities needed for developing and delivering training.

155 Singer, M.J., & Perez, R.S. (1986). A demonstration of an expert system for training device design. Journal of Computer-Based Instruction, 13(2), 58-61.

Describes the conceptual development of a decision support system for aiding in the design of training devices. The system applies expert system technology and utilizes a production rule approach. It is noted that the primary use of a training device or simulator is to provide trainees with the conditions, characteristics, and events necessary for the acquisition of skills that will be performed on the job.

059 Goldberg, I., & Khattri, N. (1987). A review of models of cost and training effectiveness analysis (CTEA). Volume I: Training effectiveness analysis (ARI Research Note 87-58). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

This research note reviews the formal predictive and prescriptive models of training effectiveness analysis and related Army guidance. Most of the models are concerned with the analytic formation of entire training programs early in the weapons systems acquisition process. Some models also include manpower, personnel, and human factors considerations. A number of models focus on the formulation of training devices and simulators. Computer Based Instruction (CBI) has not often been included in early formation of training programs for new weapons systems. Possible reasons for this finding are discussed. Most of the training program models also include a cost model, but the cost models are not necessarily adequate. The models concerned with training devices and simulators do not have associated cost models. The lessons learned included the following: 1) there are many useful models available for the formulation of training programs early in the weapons systems acquisition process; 2) the validity of these models needs to be tested, recommendations are given for comparative validity studies; 3) models for training devices and simulators appear to need further development, related cost models, and validation; 4) further attention needs to be given to formal CTEA models for advanced phases of the weapons system acquisition process, and for non-system training.

142 Ryder, J.M., Redding, R.E., & Bechschi, P.F. (1987). Training development for complex cognitive tasks. Proceedings of the Human Factors Society - 31st Annual Meeting, 1261-1265.

This study evaluated current training methodologies, particularly Instructional Systems Development (ISD), and recent developments in cognitive science to determine how training procedures should be modified to support training for tasks which require complex cognitive skills. We contend that ISD is still viable if procedures are developed for the training of cognitive skills. An important component of ISD which needs to be modified to support training of cognitive skills is the task analysis. We discuss the need for integrating efficient and cost-effective cognitive task analysis methodologies with traditional analysis methods.

158 Singer, M.J., & Sticha, P.J. (1987). Designing training devices: the optimization of simulation-based training systems. Proceedings of the 9th Interservice/Industry Training Systems Conference, 26-31.

Effective training devices are those that meet training requirements at minimum cost, or provide the maximum training benefit for a given cost. The Optimization of Simulation-Based Training Systems (OSBATS) is a model that is designed to facilitate the investigation of trade-offs involved in developing effective training device concepts. The model is based on benefit and cost approximations that are used to analyze trade-offs between various training device features in developing a device configuration, and then conducts similar trade-offs between different training device configurations. The development of OSBATS has been more theoretical than the typical decision support system or aid, but shares many of the attributes of the standard decision aid. The tools or modules that comprise the model address the following activities: a) the clustering of tasks for developing coherent training device configurations, b) the identification of optimal instructional features for a task cluster, c) the specification of optimal fidelity levels for a task cluster, d) the selection of the minimum training device family that meets training requirements, and e) the allocation of training resources in the family of suggested training devices. The final output of the OSBATS model is a functional description of the optimal set of efficient training devices given the tasks, training criteria, and cost constraints.

160 Solick, R.E., & Lussier, J.W. (1988). Design of battle simulations for command and staff training (ARI Technical Report 788). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Describes design criteria (e.g., training objectives, performance measurement, simulation requirements) for the next generation of automated battle simulation based on behavioral research on command and staff training.

158 Smith, B.R., & Banda, C.P. (1989). Use of a knowledge-based system to assess aircrew training requirements as part of conceptual design. Proceedings of the 1989 IEEE International Conference on Systems, Man, and Cybernetics.

An important consideration in developing the mission requirements and cockpit equipment for an evolving aircraft is the training needed to allow aircrews to safely and effectively operate the completed vehicle. As part of a computer-based cockpit design and analysis workstation, a prototype training assessment tool has been developed which estimates the training resources and time imposed by the anticipated mission and cockpit design. Embedding instructional system and training analysis domain knowledge in a production system environment, this tool allows crew station designers to readily determine the training ramifications of their choices for cockpit equipment, mission tasks, and operator qualifications. Initial results have been validated by comparison to an existing training program, demonstrating the tool's utility as a conceptual design aid and illuminating areas for future development.

164 Sticha, P.J., Blacksten, H.R., Buede, D.M., Singer, M.J., Gilligan, E.L., Mumaw, R.J., Morrison, J.E. (1990). Optimization of simulation-based training system: Model description, implementation, and evaluation (ARI Technical Report 896). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

A model for the optimization of simulation-based training systems was developed using systematic, top-down design procedure. The model consists of five tools that address the following problems: a) determining which tasks should be trained by part-mission devices, full-mission simulators, or actual equipment; b) specifying instructional features needed to train a set of tasks efficiently; c) specifying the levels of fidelity that should be provided along several fidelity dimensions in order to meet task training requirements and satisfy cost limits; d) determining the family of training devices that can train all required tasks at minimum cost; and e) determining the optimal allocation of training time to training devices, given constraints on device use. The tools share common data on task requirements, training device features, and costs.

A prototype decision support system was developed, and a formative evaluation was conducted. The model was demonstrated on Army rotary-wing aviation tasks, and specifications for application to armor maintenance were developed. The report describes the model using the IDEFO (Integrated Computer-Aided Manufacturing Definition) system modeling language. In addition, the model is described for an example problem from a user's perspective. The example problem illustrates the way that the OSBATS model organizes the decision process, the kinds of analyses that can be performed, and the kinds of output that are produced. It was concluded that the prototype provides an adequate interactive environment in which the developer can perform several kinds of trade-off analyses. The OSBATS software includes the data necessary to use the model for certain problems in Army rotary-wing aviation.

Analysis Methods - Additional Titles

Strategies

089 Jealous, F.S., Bialek, H.M., Pitpit, F., & Gordon, P. (1975). Developing the potential of low ability personnel (No 75-6). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Examined the scope of the learning capacity of marginal U.S. Army personnel, the longitudinal effects of long-term, self-managed learning strategies, and the proficiency levels reached as a result of the application of these strategies. Data were collected on the self-selected activities engaged in by the 24 participants and the proficiency levels reached. Considerable gains were reported in both areas for a majority of the participants. Recommendations for setting up a special individualized instruction program are listed in the event that utilization of large numbers of marginal personnel is necessary.

008 Bell, C.R. (1977). Criteria for selecting instructional strategies. Training and Development Journal, 31(10), 3-7.

Examines systematic ways of deciding which instructional approach is best for a given training program. First, training content must be developed and sequenced on the basis of needs of the organization. Environmental realities are the other major factors in training design and are defined to include cultural factors and learner characteristics. Background constraints include availability of money, time, staff, space, and equipment, with class size also to be considered. The best prepared material goes for nothing if the wrong strategy is used, and similarly an appropriate instructional strategy cannot save a weak curriculum. Increasing professionalism of the field of human resource development warrants increasing participation by training professionals in the decision-making process utilized to determine both type of training and training objectives.

044 Federico, P.A. (1978). Accommodating instruction to student characteristics: Trends and issues (NPRDC Technical Report, No Tr 79-1). San Diego, CA: U.S. Navy Personnel Research and Development Center.

Reviews the relevant professional literature concerning adaptive teaching systems. Several alternative approaches to accommodating instruction to student characteristics are identified and discussed. Several alternative approaches to accommodating instruction to student characteristics are identified and discussed. Several recommendations are made regarding what additional research and development efforts are needed to ensure the successful implementation of adaptive instructional strategies in U.S. Navy training.

052 Foley, J.P. (1979). Instructional materials for improved job performance (U.S. AFHRL Technical Report No. 78-99). Wright-Patterson Air Force Base, OH: U.S. Air Force Human Resources Laboratory.

Discusses the applicability of technologies developed by the U.S. military services for training industrial and vocational education teachers. Two types of technologies are emphasized: task oriented training (TOT) and improved task guidance and information (ITG&I). The most task oriented ITG&I are fully proceduralized job performance aids (FPJPA)- a characteristic that facilitates trade-off between FPJPA and TOT sometimes called the "head"/book trade-off. The key characteristics and requirements of the FPJPA technology are briefly described and include a formal task identification and analysis (TI&A) of each

identified task, standard language and keyed pictorials for maintenance instructions, appropriate format for the maintenance environment, and "hands on" verification of the effectiveness of each FPJPA product, utilizing Ss from the target user population. The task identification process is common to both TOT and FPJPA, and the analysis process should control the content of TOT, FPJPA, and TOT/FPJPA trade-off. Samples of ITG&I, including FPJPA, are displayed but it is cautioned that content of instructional materials placed in this format must be controlled by the developmental process. Industrial applications of the ITG&I and TOT technologies and implications for vocational and industrial teacher education are described.

150 Shields, J.L., Joyce, R.P., & VanWert, J.R. (1979). Chaparral skill retention (Research Report 1205). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Examined retention of Chaparral missile crewmen skills to determine the most effective schedule of refresher training. Six tasks included in the Soldier's Manual were evaluated using hands-on performance (P) tasks, which were completed using the appropriate technical manual (TM). 99 U.S. Army soldiers were divided into 3 experimental groups. All Ss were tested immediately after completing Advanced Individual Training (AIT), were tested and trained to standard on arrival at the Chaparral unit, and were retested 4 months later. Groups 1 and 2 were also retested and trained 1 and 2 months post arrival, respectively. Group 3 received no additional testing or refresher training. Feedback given to Ss following the first testing apparently provided training so that P improved over the interval between AIT and first unit testing. P declined slightly thereafter, suggesting that once Ss learned to perform the task to standard using the TM, they continued to perform at or near standard over the 4-month interval. It is suggested that the required frequency of training to maintain proficiency in these tasks probably would have been much greater had the TM not been used.

151 Shields, J.L., Goldberg, S.L., & Dressel, J.D. (1979). Retention of basic soldiering skills (ARI Research Report 1225). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Field Artillery Training Center evaluators (Es) tested 523 soldiers' performance on 20 basic common tasks. Ss were either in the process of completing entry-level training or had completed training during the previous 12 months. Es rated task performance "GO" or "NO GO" for each task step and for the task as a whole. Tasks varied in the rate at which percent of "GO" declined since training. Three factors accounted for most of the differences in retention: number of task steps, order of original training, and the presence or absence of subtasks. Task steps that tended to be forgotten were those that were not suggested by the previous sequence of steps or by the equipment. It is suggested that findings can be used to maintain desired levels of proficiency in critical skills and to determine which tasks require frequent training.

054 Gade, P.A., Fields, A.F., Maisano, R.E., & Marshall, C.F. (1980). Training approaches and data entry methods for semi-automated command and control systems. Proceedings of the Human Factors Society-24th Annual Meeting.

In Experiment I, a response-sensitive instructional strategy was compared to more traditional instructional strategies in an embedded training program designed for manual data entry operators in the Army TOS command and control system. Results showed that using the response-sensitive strategy reduced

training time without reducing inputting accuracy. Experiment 2 examined the relative efficiency of four different manual data entry methods: Typing, Typing with an error corrector, Menus, and Auto-completion with an English option. Results show that Menus are the most accurate inputting method. No differences were found in entry time among the methods. Results also showed little agreement between preference and performance of the methods.

120 Morrison, J.E., & Goldberg, S.L. (1982). A cognitive analysis of armor procedural task training (ARI Technical Report 605). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Compares traditional and performance-oriented approaches to procedural training and notes their deficiencies. A cognitive interpretation of procedural learning is advanced, and training implications are discussed. Representative armor procedures are analyzed to derive the underlying memory structures required for recall. Specific training applications of the memory structures that might help the soldier learn and remember a procedure (e.g., "part-task" training; association of subgoal names with subprocedures) are discussed.

144 Schendel, J.D., & Hagman, J.D. (1982). On sustaining procedural skills over a prolonged retention interval. Journal of Applied Psychology, 67(5), 605-610.

Examined the relative costs and benefits of 3 alternative approaches for sustaining procedural skills over a prolonged retention interval and whether individuals can estimate in advance of retention testing how much refresher training they require to regain proficiency. 38 Army reservists were assigned to groups according to their past experience on the experimental task-disassembly/assembly of a machine gun. One group was trained to criterion and then received 100% initial overtraining. This group's 8-week retention and retraining performance was compared against that of a group that received the same amount of additional training midway through the retention interval. The control group trained to criterion but received no additional training prior to retention testing and retraining. Refresher training estimates were collected immediately prior to retention testing. Cost effectiveness considerations weighed heavily in favor of the overtraining group. Ss appeared to know how much refresher training they required to regain proficiency.

036 Dossett, D.L., & Hulvershorn, P. (1983). Increasing technical training efficiency: Peer training via computer-assisted instruction. Journal of Applied Psychology, 68(4), 552-558.

Conducted two studies of peer training via computer-assisted instruction (CAI) in the technical training of electronics in the military. Ss were 182 male U.S. Air Force personnel. Study 1 compared a peer-training CAI group (n = 72) to both an individually trained CAI group (n = 55) and a conventionally trained group (n = 55). Results indicate no differences in achievement levels, but the mean training times of both CAI groups were significantly less than that of the conventionally trained group. The mean peer-trained CAI training time was significantly lower than that of the individually trained group, and the variability of training time was also significantly lower. Exp. II, using the peer-trained subsample from Exp I and an additional 48 Ss, investigated optimum pairing strategies. Ss were paired for training based on their previously demonstrated ability. Pairing strategies did not affect

individual achievement scores, but some strategies were consistently superior in reducing training times. Implications of CAI peer training in both military and civilian technical training are discussed.

066 Hagman, J.D., & Rose, A.M. (1983). Retention of military tasks: A review. Human Factors, 25, (2), 199-213.

Discusses 13 experiments conducted or sponsored by the U.S. Army Research Institute for the Behavioral and Social Sciences. These experiments examined the retention of military tasks performed in an operational environment and provide empirical data on the effects of method, task, and ability variables that influence attempts to improve retention through training. These data provide information useful to trainers and training-program developers in deciding how, what, and whom to train to enhance retention and to achieve greater training management effectiveness.

092 Johnson, W.B., & Fath, J.L. (1983). Design and initial evaluation of mixed-fidelity courseware for maintenance training. Proceedings of the Human Factors Society-27th Annual Meeting, 1017-1021.

Results are reported of a project which involved the design of computer-based courseware for maintenance training. The courseware includes a training simulation which combines two levels of fidelity. The microprocessor-based courseware was developed for troubleshooting training on an electronic telephone switchboard at the U.S. Army Signal School in Fort Gordon, Georgia. Initial evaluation of the courseware demonstrated that computer-based simulation can be effectively used to supplement or partially replace "hands-on" practice with real equipment. Practice on the simulation, interspersed with real equipment practice, added a new and valuable dimension to the diagnostic training.

101 Knerr, C.M., Keller, S.D., & Laurence, J.H. (1984). Training strategies for the M1 Abrams tank driver training (ARI Research Report 1383). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Classified M1 Abrams tank driver-trainer (DT) tasks according to the training effectiveness and cost effectiveness prediction model that prescribes learning guidelines based on behavioral activities, conditions, standards, and feedback of the tasks. Most of the tasks were procedural, but many procedures required voice communications, decision making, or both. One set of the DT program presented the continuous movements tasks of driving such as steering. Some learning guidelines were common to all DT tasks (e.g., providing active practice and feedback), while others were specific to the type of task (e.g., high fidelity, continuous feedback for continuous movement tasks). Potential DT features pertained to all tasks (e.g., scoring tasks) or to specific tasks (e.g., increasing the number and repetition of decision-making tasks). Integration of the DT into the program of instruction considers use of the M1 tank technical manual, new programs orienting the trainee to the driving block of instruction and the driver's intercom, and changes in the device hardware and software.

180 Wrightman, D.C., & Lintern, G. (1985). Part-task training for tracking and manual control. Human Factors, 27, (3), 267-283.

Reviews the effectiveness of part-task training for low-aptitude or inexperienced students and establishes a conceptual structure to guide research. Issues pertaining to tracking in manual control are emphasized. Transfer of training is emphasized, and crucial features of the methodology and of means of assessing transfer are also discussed. The part-task procedures of segmentation, fractionation, and simplification are explained, and procedures for reintegrating parts into the whole task are summarized. Implications for video-gaming skills are noted.

024 Ciaverelli, A.P. (1986). Instructional strategies for improving training system effectiveness. Proceedings of the Human Factors Society- 30th Annual Meeting, 144-148.

Advanced simulators and other training systems have been designed to replicate as realistically as possible various operational systems and environments. The rationale for this particular design goal is to attain sufficient fidelity for maximum training transfer to the real world. Yet, effective training may not only depend on attaining adequate fidelity, but also upon how a given training system is used to achieve specific learning outcomes. This paper identifies some of the salient problems with training system design and use, and discusses possible solutions for improving their training value based on incorporating instructional support capabilities and using prescriptive instructional methods.

087 Hunt, J.P., & Evans, K.L. (1986). The development and evaluation of a moving target engagement training program with the M16A1 rifle. Proceedings of the Human Factors Society - 30th Annual Meeting, 285-289.

This proposal reports the findings of one of a series of eight experiments concerned with improving the soldier's ability to engage moving personnel targets. This overall research effort examined the effect of different modes of fire, additional ammunition, methods of target engagement, the use of an intermediate live-fire exercise, and the use of device-based training on moving target engagement. Current U.S. Army training for Infantrymen includes one day of instruction in moving target engagement. This experiment describes a modifies training program with special training devices conducted over a two-day period.

137 Roman, J.H., Pistone, R.A., & Stoddard, M.L. (1986). A trilevel interactive design model for pilot part-task training. Proceedings of the Human Factors Society - 30th Annual Meeting, 126-130.

Development of effective, scenario-driven training exercises requires both an instructional design and a delivery system that match the subject domain and needs of the students. The Training Research Team at Los Alamos National Laboratory conducts research and development of prototype training systems. One of the Team's efforts is a joint research project, supported with funding and behavioral science guidance from the Army Research Institute, to develop a prototype part-task trainer for student helicopter pilots. The Team designed a "trilevel interaction" model and a Level III interactive video disk delivery system for this project. The model, founded on instructional and psychological theory, should be transferable to other domains where part-task training is appropriate.

116 Mayer, S.J., & Russell, J.S. (1987). Behavior modeling training in organizations: Concerns and conclusions. Journal of Management, 13(1), 21-40.

Reviews studies of behavior modeling (BM), a popular training methodology in organizational settings. It is concluded that the reasons for BMs effectiveness are not as clear as supposed and that there are 4 issues that remain unresolved: (1) Internal and external threats to validity from field research are minimal, but variations in training programs do not rule out threats to the construct validity of behavioral and performance improvements in the work place. (2) There is no evidence that BM is more cost effective than other training methods. (3) A variety of BM techniques is used in the training programs, and little study has been completed on which techniques are the most effective. (4) No studies have examined the long-term shifts in the values and attitudes of trainees. Future research should focus on these concerns in evaluating the utility of BM methodology in organizational training and development interventions.

Strategies - Additional Titles

Crew and Team Training

075 Harris, J.H., Osborn, W.C., & Boldovici, J.A. (1977). Reserve component training for operating and maintaining the M48A5 tank (ARI Technical Report 77-A14). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Identifies constraints to consider in planning National Guard tank training and presents an outline for a crew-level program for the M48A5 tank, using existing training materials as much as possible. The Crew Interaction Performance Test and Duty Position Readiness Tests were developed to measure individuals' proficiency in a crew environment and their ability to perform 4 crew tasks, respectively.

152 Shriver, E.L., Jones, D.R., Hannaman, D.L., Griffin, & Sulzen, R.H. (1979). Development of small combat arms unit leader tactical training techniques and a model training system (ARI Research Report 1219). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

This research developed simulation techniques for small-unit leaders and tactical decision making while minimizing troop participation. Basic instructional principles underlying engagement simulation were used to construct a map board game abstraction of field exercises. The game was a two-sided, free-play map exercise for teaching infantry tactics to platoon leaders. As originally conceived, junior officers could play the game to learn tactical skills which they would later apply during REALTRAIN exercises of troops.

However, for best results leaders appeared to need to learn to work with their noncommissioned officers (NCOs) and then to practice in the field, both with and without troops. A variation of the basic game enabled the unit team of platoon and squad leaders to work together on the game board as they would during an actual engagement.

Concurrently, a field training technique, focused on leader/subordinate interaction, was explored. The field opposition exercise involved only key leaders on each side, without troop support.

A combined arms map board game was also developed to help familiarize junior officers with the nature of tactical operations that integrate mechanized infantry, armor, and anti-armor elements against a deployed enemy.

The research summarized in this report has produced (a) an infantry squad/platoon level map board game for two-player or multiplayer use; (b) an infantry squad/platoon level field opposition exercise; and (c) a combined arms platoon/company level map board game. Separate documents are available on each of the three training techniques.

046 Finley, D.L., & Dyer, J.L. (1980). Army teams: Who are they and how do they function? Proceedings of the Human Factors Society - 24th Annual Meeting.

The Army Research Institute Field Unit at Fort Benning has initiated a long range research program in the areas of team training and evaluation. The focus is on small (2-11 persons), formally recognized, Army work teams in the combat and combat support branches. The overall research game plan is to

concentrate on identifying: (1) What it is that constitutes team, as opposed to individual, performance; (2) Which of these team performance skills can be modified by training and also serve to determine team output; (3) Analytic and assessment techniques for identifying and evaluating these skills; and (4) Team training techniques appropriate for Army conditions. The anticipated final research products include Instructional Systems Development (ISD) techniques and guidance regarding team training program development, team performance assessment techniques, and improvement and/or development of selected team training and assessment programs.

The purpose of this presentation is to report on two steps that have been accomplished in this program thus far. The first of these is the development of an inventory of Army teams. The second is a preliminary identification of what constitutes team performance at the functions level.

033 Denson, R.W. (1981). Team Training: Literature review and annotated bibliography (Technical Report No. 80-40). U.S. Air Force Human Resources Lab, Logistics & Technical Training Div., Wright-Patterson Air Force Base, OH: U.S. Air Force Human Resources Lab.

Reviews government documents, industry reports, journal articles, and books on team training, to determine what is currently known and to identify unresolved issues relevant to team training by the U.S. Air Force. Documents dated before 1960 and social-psychological studies of small group behavior are limited to a few review articles. Topics covered by the documents reviewed are definitions; individual, task, and team characteristics; organization and structure of teams; feedback; objectives, measurement, and evaluation of team training; and the development of instructional systems for effective training. The appendix contains an annotated list of 129 items.

034 Denson, R.W. (1981). Team training: Literature review and annotated bibliography. Catalog of Selected Documents in Psychology, 11, 92.

086 Hritz, R.J., Roth, J.T., Lewis, C.M., Finley, D.L., Dyer, J.L., & Strasel, H.C. (1983). A generic model for evaluating team performance. Proceedings of the Human Factors Society - 27th Annual Meeting, 1048-1052.

The purpose of this paper is to discuss a model or methodology for evaluating the proficiency or performance of military teams. The methodology is appropriate for evaluating the performance of any team type performing any of its assigned mission. The methodology contains procedures for assessing both team process (team behavior) and team outcome (team success). Application of the methodology to a specific team performing a specific mission generates information which is useful in identifying team training deficiencies and in establishing team training requirements. The procedure is also useful for assessing the effects of team training, i.e., for measuring the amount and kind of team proficiency realized as a result of specific training.

168 Swezy, R.W., & Salas, E. (1987). Development of instructional design guidelines for team training devices. Proceedings of the Human Factors Society - 31st Annual Meeting, 97-101.

Both the research data base and practical experience, indicate that engineers involved in the design and development of team training devices either have inadequate access to, or for other reasons do not typically use, human factors and instructional design principles. This paper discusses a project whose purpose is to: (1) identify team processes and characteristics which may be

employed in the design of team training devices, (2) state this information in guideline form, and (3) begin the development of a taxonomy of team training design characteristics which may be used to organize the guidelines.

138 Stout, R.J., Cannon-Bowers, J., Morgan B.B., & Salas, E. (1989). The development of a scale to assess the teamwork needs of training situations. Proceedings of the Human Factors Society - 33rd Annual Meeting, 1268-1272.

Operational studies have revealed a need to focus attention on team training, and a need for effective teamwork skills for successful training performance. The present study was designed to develop an assessment scale that can be used by instructors of various training situations, which will yield a measure of the degree of teamwork required in their situations. Data obtained from the scale show psychometrically sound properties of the scale (high internal consistency and high item-total correlations) and initial validity of it (the ability to distinguish various training situations as to the extent of teamwork that is required). Recommendations for future research are also discussed.

Crew and Team Training - Additional Titles

Leader and Instructor Training

175 Wellins, R.S., Rumsey, M.G., & Gilbert, A.C. (1980). Analysis of junior officer training needs (ARI Research Report 1236). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Results from interviews and surveys indicate that most problems described by U.S. Army junior officers and corroborated by noncommissioned officers and enlistees were of an interpersonal and organizational nature (e.g., relationships with subordinates, military justice, discipline). The training and courses that cadets received in these areas were rated as extremely valuable. Data suggest several ways to improve precommissioning training, including a greater interaction with active Army personnel; more on-the-job experience before commissioning; the use of problem-oriented, realistic training; and more emphasis on interpersonal, "soft-skill" training.

035 DiPaolo, A.J., & Patterson, A.C. (1983). Selecting a training program for new trainers. Training and Development Journal, 37(1), 96-101.

To assist training directors in selecting the most appropriate programs for their personnel, the basic competencies for the inexperienced trainer were identified and 37 "train the trainer" packages were analyzed. Many weaknesses in these training programs were noted, including a failure to match program content to the organizational setting, a lack of participant self-assessment and diagnostic procedures, and the omission of a formal program follow-up evaluation and behavior maintenance component. The specific skills that new instructors should gain from training programs include an understanding of adult learning and motivational techniques, communication, and correct use of media and resources during presentation.

PREDICTION AND EVALUATION OF STUDENT AND MEDIA PERFORMANCE EFFECTIVENESS

Prediction

176 Wheaton, G.R., Mirabella, A., & Farina, A. (1971). Trainee and instructor task quantification: Development of quantitative indices and a predictive methodology (NAVTRAEQUIPCEN No. 69-C-0278-1). Orlando, FL: Naval Training Equipment Center.

An exploratory study was undertaken, as part of a program to develop quantitative techniques for prescribing the design and use of training systems. As a first step in this program, the present study attempted to (a) compile an initial set of quantitative indices, (b) determine whether these indices could be used to describe a sample of trainee tasks and differentiate among them, (c) develop a predictive methodology based upon the indices, and (d) assess that methodology using studies in the literature. The compilation included the display-evaluative index, a set of panel layout indices, and a set of task rating scales. These indices were applied to task analytic data, collected on sonar operator trainers. Application of the indices proved feasible, and differentiation among 3 training devices, and within 4 trainee subtasks (set-up, detection, localization, classification) was possible. The predictive method which was generated was an adaptation of the standard multiple regression model. Mean task scores replaced the usual individual criterion scores, and quantitative task index values were used as predictor scores. This adaptation was tested using data from published studies on tracking. Significant multiple correlations using task indices were found for criterion data obtained during early stages of practice. A combination of task and training indices did predict later performance. This result supported the contention that a prescriptive method must include "training" as well as "task indices" in order to account for advanced levels of proficiency.

124 Neal, G.L., Dannhaus, D.M., Tierney, T.J., & Cartner, J.A. (1977). First may or may not be best, or cost and training effectiveness analysis in comparing training approaches. Proceedings of the Human Factors Society - 21st Annual Meeting.

In the future the human factors specialist can expect to plan and conduct economic analysis-oriented training studies called cost and training effectiveness analysis (CTEA). This paper enumerates basic CTEA principles and describes a basic rifle marksmanship training study to illustrate their application.

100 Klein, G.C., Kane J.J., Chinn, A.A., & Jukes, A.O. (1978). Analyzing training device effectiveness in cases where test data is inconclusive. Proceedings of the Human Factors Society - 22nd Annual Meeting, 152-156.

Budgetary and time constraints continue to turn the trainer toward the use of simulative devices in designing training programs. Sophisticated devices engineered to simulate often complex man-machine interfaces usually are major investments for the Government Agency or Corporation who use them. How can the user ensure that the device is, in fact, worth the investment? The obvious answer to the question is to conduct prototype testing using representative students to measure the degree of Training Transfer. Testing requires a further substantial investment, however, in terms of both time and money. In many cases, proper test data is just not available. Can device effectiveness be measured when marginal test data or no test data at all exists? The authors, through four successive Cost and Training Effectiveness

Analyses commissioned by the United States Army, have attempted to make training effectiveness assessments in just such cases. Through the application of a behavioral predictive model known as TRAINVICE (Wheaton, 1976), they have been moderately successful in determining device utility in terms of potential training transfer. This paper specifically discusses the most recent study, that of the Ground/Vehicular Laser Locator Designator and its associated prototype trainer. The paper describes the test data available at the beginning of the study, discusses the strengths and weaknesses of the TRAINVICE Model as applied in the study, and contributes some thoughts pertaining to the future directions that studies of this nature might take.

022 Carter, G., & Trollip, S. (1979). A constrained maximization extension to incremental transfer effectiveness, or, How to mix your training technologies. Proceedings of the Human Factors Society - 23rd Annual Meeting.

The incremental transfer effectiveness concept can be extended to a constrained maximization context by replotting the data to form a set of iso-transfer contours and adding constraints to this same graph as binding linear functions. This transformation permits an analytically elegant solution to maximizing transfer of training dynamically constrained by financial, environmental, reliability, or other restricting factors for any number of instructional technologies through application of the Lagrange Multiplier method. Alternatively, the dual problem of finding the minimum value of these constraints can be solved to achieve a specified transfer of training. An example of applying the Lagrange Multiplier method to training is provided and the potential usefulness of mathematical programming techniques noted. This extension is particularly useful in complex training environments involving numerous instructional technologies or frequently changing constraints. In the single instructional technology case, this extension provides additional graphical insight into the trade-offs involved in designing cost-effective training programs.

111 Maitland, A.J. (1980). Using predictor equations to assess potential performance of armor enlistees (ARI Research Report 1240). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Examines research findings on predicting the performance of U.S. Army armor crewmen and shows how these findings may be applied in the current training program. Results of various methods of assigning groups of enlistees to training programs illustrate the effects of different decision rules on the end-product of training. With the method of prediction supplied in this review, the performance potential of groups of enlistees may be assessed from readily available test scores, and the result of assigning these individuals to different training programs may be estimated.

115 Matlick, R.K., Berger, D.C., Knerr, C.M., & Chiorini, J.R. (1980). Cost and training effectiveness analysis in the Army life cycle systems management model (ARI: Litton Mellonics TR 503). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

This report examines the requirements and purposes of cost and training effectiveness analysis (CTEA) in the context of the Army's Life Cycle Systems Management Model. Current CTEA methodologies are examined. Methods to augment existing models are developed and a general synthesized model for use by CTEA analysts is proposed.

032 Dawdy, E.D., & Hawley, J.K. (1982). A forecasting method for training effectiveness analysis. Proceedings of the Human Factors Society - 26th Annual Meeting, 250-254.

In dealing with emerging materiel systems early in their life cycle, the selection of an acceptable training program often requires the use of a training effectiveness forecast methodology. Methods traditionally used to determine training effectiveness require data that are not available until after many important training-related decisions have been made. A training effectiveness forecasting method is described that combines the development of viable training program alternatives, the estimation of individual task training effectiveness, the estimation of training program effectiveness, and the integration of cost data to determine the most cost-effective training approach. The methodology has the advantage of fixing neither effectiveness nor cost. Rather, the procedure allows for later consideration of either constraint as part of the selection criterion. Although the emphasis of the presentation is on the estimation of training effectiveness, extended uses of the resulting data are noted, including assessing trainability, training time requirements, and requirements for maintenance or refresher training.

125 Neal, G.L. (1982). Overview of training effectiveness analysis. Proceedings of the Human Factors Society - 26th Annual Meeting, 244-248.

U.S. Army Training and Doctrine command (TRADOC) training effectiveness analysis (TEA) began in 1975 and has evolved into today's TRADOC TEA System. An overview of the TEA System history, characteristics, methodology, scope, and lessons-learned are presented in this paper.

172 Tufano, D.R., & Evans, R.A. (1982). The prediction of training device effectiveness: A review of Army models (ARI Technical Report 613). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

This report is a critical review of the analytic models which have been developed by the Army to predict training device effectiveness. In particular, special consideration is given to a family of models known collectively as TRAINVICE. Although they are all intended to provide an index of transfer potential, these four models differ in several important ways. The variables considered in the calculation of the indices are given different degrees of emphasis (or weight) in each model. In fact, in some cases a variable is ignored completely, e.g., the instructional features of a training device. The preparatory analyses employed to estimate the values of each variable change a great deal from model to model. Moreover, the combinatorial procedures used to calculate an index of effectiveness from the variable values are very different in each mod goal of this report is to present the principal points of difference among the various predictive models, and thus facilitate a comparative assessment of their merit. The results of the analysis and subsequent validation will provide a basis for the selection/ refinement of one or more of the models for incorporation into a defined set of procedures for specifying training device effectiveness.

102 Knerr, C.M., Nadler, L.B., Dowell, S.K., & Tufano, D.R. (1983). Comparison of training transfer and effectiveness models. Proceedings of the Human Factors Society - 27th Annual Meeting, 906-910.

The costs of training devices and simulators have induced the military to formulate models for predicting the training effectiveness, including training transfer effectiveness, of devices during their design and development. Analysis of existing models compared them on the following dimensions: objectives, components, units of analysis, metrics, and development. Development included level of completion, validation, and automation. The models analyzed were those for predicting effectiveness or prescribing device characteristics rather than military Instructional Systems Development (ISD) model and the Navy's Training Effectiveness and Cost Effectiveness Prediction model. Other models were the Training Device Effectiveness model (TRAINVICE); Training Efficiency Estimation Model; training resource estimators; manpower, personnel, and training estimation models; multi-attribute utility estimation; and methods for specifying training device features. Most of the models were prescriptive, rather than predictive, of effectiveness. Few (including TRAINVICE) estimated transfer to the operational setting.

103 Knerr, C.M., Nadler, L.B., & Dowell, S.K. (1984). Training transfer and effectiveness models (AIR: HumRRO Final Report). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Several models have been developed to predict training effectiveness or training transfer to performance on operational equipment. One model, TRAINVICE, is undergoing validation and improvement. This report compares TRAINVICE and other models to identify techniques and components to augment those in TRAINVICE.

Review of the literature and contacts with cognizant scientists identified the following models for comparison:

Training Effectiveness and Cost Effectiveness Prediction (TECEP)

Instructional Systems Development (ISD)

Training Device Specification Models
- Training Device Design Guide
- Taxonomy of Training Device Features
- How to Determine Training Device Requirements and Characteristics

Simulator Training Requirements and Effectiveness Study (STRES)

Cost and Effectiveness Analysis of Training Programs
- Training Efficiency Estimation Model (TEEM)
- Training Consonance Analysis (TCA)
- Training Developer's Decision Aid (TDDA)
- Training Development Decision Support System (TDDSS)

Manpower, Personnel, and Training (MPT) Estimation in the Systems Acquisition Process
- Cost and Training Effectiveness Analyses (CTEA) in Army Material (sic) Acquisition
- Military Manpower and Hardware Procurement (HARDMAN)
- Method of Designing Instructional Alternatives (MODIA)
- Training Requirements Analysis Model (TRAMOD)

The analysis compared the models on five dimensions: Objectives, units of analysis, components, metrics, and level of development.

Objectives and units of analysis divide the models into two groups: those pertaining to features within training devices and those pertaining to whole training programs. Predictive models tend to have more quantitative measures and metrics than prescriptive ones. Models that rely on subjective judgments may better distinguish among alternative designs if they use comparative judgments (rather than the composites of absolute judgments currently used). Most of the models have not been validated, and cannot be unless measures of criteria can be developed and applied.

Future research on predictive and prescriptive models of training effectiveness and transfer can use the comparisons for potential model components, methods, and applications.

109 Levinson, E.D., & Donovan, M. (1984). Simulator fidelity specification based on training needs. Proceedings of the Human Factors Society - 28th Annual Meeting, 142-146.

This report summarizes the work to date on a simulator qualification methodology project. The development of a simulator qualification process, based on a training perspective, is described so that it can be used on other qualification projects. The measures used to quantify the simulator's performance are provided and the results of demonstration analysis are described.

128 Pitts, E.W., Salas, E., Terranova, M., Allen, G.L., & Morgan, B.B.(1984). Dynamic measures of potential training success. Proceedings of the Human Factors Society - 28th Annual Meeting, 855-859.

The Armed Forces and other large organizations often use scores from standardized aptitude batteries as indicators of cognitive aptitude. However, aptitude may also be demonstrated by the learning that occurs during training and measured by parameters such as initial ability levels and time needed to acquire information or skills. By using computer administered Complex Experimental Learning Tasks (CELTS), learning rate parameters recently have proved to be pragmatic as well as theoretical indicators of final performance. Potential advantages of this approach include ease and economy of computer administration, testee acceptance of job relevant tests, and potential benefits of shortened training schedules. The current research compared rate measures derived from learning on four CELTs with a paper-and-pencil battery designed to include static aptitude measures of the same domains. Performance measures were computed from stimulus display times, subject response time, and item accuracy. Overall final performance was computed using the average of the last five minutes. Correlational analyses and regression indicate that, with some qualifications, learning rate measures are predictors of individual and overall levels of performance on each CELT. Implications of these findings are that the current practice of using static aptitude tests for selection to training programs may not provide the most accurate picture of an individual's potential success or failure in that program, and that, given the trend towards new computer-assisted training technologies, individuals may be selected on the basis of their potential for rapid learning, thus making use of the least expensive and most efficient training methods possible.

126 Neal, G.L., & Paris, T.L. (1985). The contribution of training effectiveness analysis in the Army. Proceedings of the Human Factors Society - 29th Annual Meeting.

The U.S. Army Training and Doctrine Command's (TRADOC) Training Effectiveness Analysis (TEA) System studies assume that measured soldier job performance is a function of the interaction of five factors: the soldier, the trainer, the training subsystem, the hardware subsystem, and the training environment. Examples of how this assumption guides TEA studies and contributes to the analysis of Army training effectiveness are provided.

138 Rose, A.M., Wheaton, G.R., & Yates, L.G. (1985). Forecasting device effectiveness: I. Issues (ARI Technical Report 680). Alexandria, VA: U.S. Army Institute for the Behavioral and Social Sciences.

Discusses issues that bear on the development of formal analytic methods for predicting the potential effectiveness of alternative training devices. Theoretical issues discussed include the meaning of the term "device effectiveness," how transfer of training is measured, its use as a measure of device effectiveness, and alternatives to transfer of training as measures of effectiveness.

139 Rose, A.M., Wheaton, G.R., & Yates, L.G. (1985). Forecasting device effectiveness: II. Procedures (ARI Research Report 85-25). Alexandria, VA: U.S. Army Institute for the Behavioral and Social Sciences.

Describes an analytic training device effectiveness forecasting technique (DEFT) that accounts for device effectiveness in terms of several different criteria and classes of independent predictor variables. In its present form, DEFT is a series of interactive, menu-driven computer programs that provide for three levels of device evaluation that are chosen as a function of the type of input data that are available and the degree of diagnosticity that is needed. A DEFT user's manual and listings of DEFT programs are appended.

140 Rose, A.M., Martin, A.W., Yates, L.G. (1985). Forecasting Device Effectiveness (Volume 3) (ARI Technical Report 681). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences

Several analytic procedures were conducted to address various aspects of the scalar properties of the device effectiveness forecasting technique (DEFT). these procedures included Monte Carlo simulations to assess the interpretation of DEFT output, sensitivity of DEFT parameters, comparison of outputs, stability, and inter-rater agreement. Results indicated that it would be necessary to incorporate assumptions regarding expected distributions of input variables in order to meaningfully interpret DEFT output. Also, the Monte Carlo analyses demonstrated the sensitivity of DEFT output scores to variations in inputs, and assessed the effects of various assumptions regarding measurement error on output scores. The inter-rater agreement issue was addressed by having several raters apply DEFT to the three actual training devices. Results indicated a high degree of consistency among raters for all devices for all levels of DEFT.

145 Schendel, J.D., Heller, F.H., Finley, D.L., & Hawley, J.K. (1985). Use of Weaponeer marksmanship trainer in predicting M16A1 rifle qualification performance. Human Factors, 27, (3), 313-325.

In Exp I, 69 initial entry soldiers were assigned to 3 groups varying in Weaponeer target scenario difficulty and were tested twice on a scenario prior to firing record fire (RF). Weaponeer performance under the most difficult scenario appeared to be the best predictor of RF performance. Predictions improved when later shots and firing positions were considered on the device. In Exp II, 2,244 permanent party troops were divided into 5 groups according to amount and type of prior training on Weaponeer. Results indicate that Weaponeer can be used to predict RF performance as long as training is not provided immediately prior to Weaponeer testing.

090 John, P.G., Klein, G.A., & Taynor, J. (1986). Comparison-based prediction for front-end analysis. Proceedings of the Human Factors Society-30th Annual Meeting, 149-153.

Comparison-Based Prediction is a formalized method for using analogical reasoning to generate estimates early in conceptual design and planning. Its feasibility has been demonstrated for structuring expert judgment in a variety of domains, including human factors applications such as predicting the effectiveness of training devices.

002 Adams, A.V., & Rayhawk, M. (1987). A review of models of cost and training effectiveness analysis (CTEA). Volume II: Cost analysis (ARI Research Note 87-59). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Cost and training effectiveness must be considered jointly in considering how to meet training requirements. Cost predictions for various training alternatives are not at their most valuable in the early stages of a weapon system's life-cycle, and this report discusses the problems encountered with data availability at this stage. A cost model must incorporate economic concepts as opposed to purely accounting costs. The economic ideas embedded in CTEA are discussed, and the search for, and difficulties in developing and applying, a generic CTEA model are addressed. Finally, building on earlier reviews, 17 cost models and guidebooks are examined in terms of purpose of development, features included, usefulness in the early stages of weapon system development, and strengths and weaknesses of the model or guidebook. In a summary on the lessons to be learned, the more advanced state of training effectiveness development is noted; suggestions are made for new research on costing; continued early coordination between system designer, training developer, and cost analyst is advocated; and comparison-based methods are recommended as one means to address data problems in the early stages of system development.

018 Cantor, J.A. (1988). Research and development into a comprehensive media selection model. Journal of Instructional Psychology, 15(3), 118-131.

Describes an instructional systems media selection model based on training effectiveness and cost effectiveness prediction techniques developed to support the U.S. Navy's training programs. The process is a 2-stage model that addresses both training and cost effectiveness considerations in selecting an instructional delivery system.

060 Goldberg, I. (1988). Training effectiveness and cost iterative technique (tecit) Volume I: Training effectiveness analysis (ARI Research Note 88-35). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

This research note describes the effectiveness model of the Training Effectiveness and Cost Iterative Technique (TECIT), a new model concerned with the cost effectiveness of training devices and simulators (TD/S) at all phases of the life cycle development. Volume II describes the cost model.

For the purposes of this study, the effectiveness of a training device or simulator was defined as a function of the following factors: safety, acquisition learning on the TD/S, transfer of training from the TD/S to an exercise on the weapon system during training, job or battle readiness, and the utilization ratio of the TD/S.

A research strategy is outlined in the research note. This strategy considers cross-sectional and longitudinal designs, TD/S life cycle phases, and various validity designs (e.g. discriminant, concurrent, and predictive validity). Sampling of subject matter experts' opinions and TD/S is also considered.

Also included in this document is a review of related models, including the Device Effectiveness Forecasting Technique (DEFT), Forecasting Training Effectiveness (FORTE), and Comparison Based Prediction (CBP). A comparison of model features is also included, along with sample questionnaires, and an illustrative data base.

003 Adams, A.V, & Rayhawk, M. (1988). Training effectiveness and cost iterative technique (TECIT) Volume II: Cost effectiveness analysis (ARI Research Note 88-57). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

This research note discusses an important issue, the training of soldiers in the use of a weapon system, which is important to the operational cost and success of the system in the carrying out of its mission. Cost and Training Effectiveness Analysis (CTEA) models formalize the process of choosing among alternative training technologies by comparing the cost and training effectiveness of these technologies. In this report, an economic framework is presented for integrating cost and training effectiveness data for CTEA studies. The framework builds on transfer effectiveness models and offers a model for the effectiveness of cost-minimizing training technologies. The model is particularly well-suited to the selection of training technologies for tasks that are trained on weapons systems whose operation is costly or life threatening. The research note shows how cost data would be developed for the model in evaluating computer-assisted instruction as a training technology for the M1 Abrams tank.

027 Companion, M.A., Carson, R., Garris, R. (1990). ASTAR Operational Evaluation Report (NAVTRASYSCEN Special Report 90-005). Orlando, FL: Naval Training Systems Center.

The Automated Simulator Test and Assessment Routine (ASTAR) is an automated decision aid designed to assist a training system analyst in the prediction of the effectiveness of training devices. ASTAR was developed to provide a systematic and analytic evaluation procedure to aid training device design and acquisition. Prior to implementation as a standard evaluation technique, it was necessary to conduct field tests with operational analysts to determine user acceptance of ASTAR. The objective was to compare and contrast ASTAR to

other automated Device Effectiveness Technologies (DETs) and, if warranted, to formulate a plan to implement ASTAR as a standard evaluation technique within the DoD Instructional System Development (ISD) process. The operational evaluation was accomplished through three operational tests and a longitudinal test using operational training systems and their analysts. The tests examined performance, utility, and user issues with regard to ASTAR, and Media Selection (AIMS) System. while the concept of ASTAR was well received by the operational analysts, the current implementation of ASTAR achieved poor user acceptance. ASTAR requires extensive enhancement before it can gain general approval. A Functional Description (ASTAR Operational Evaluation: Conclusions and Recommendations, Companion, 1991) for an improved ASTAR (ASTAR II) was developed which addressed the problems of ASTAR. It is recommended that any further developmental action on ASTAR be limited to consideration of ASTAR II.

028 Companion, M.A. (1991). ASTAR Operational Evaluation: Conclusions and Recommendations (NAVTRASYSCEN Special Report 90-004). Orlando, FL: Naval Training systems Center.

The Automated Simulator Test and Assessment Routine (ASTAR) is an automated decision aid developed to provide a systematic evaluation procedure to aid training device design and acquisition. ASTAR was "field tested: by training analysts to provide joint services operational evaluation of the device prior to its being widely distributed. The results of the operational tests indicated that the current ASTAR program is unacceptable for widespread use, although the concept of a decision aid for training analysts was met with enthusiasm. The problems with ASTAR were primarily with the user interface. The problems with ASTAR were primarily with the user interface. The program is cumbersome and tedious to use, and the output is hard to interpret. There is also a problem with the current compiler which precludes smooth operation on the 80286 (like the Zenith 248) class computers. It is recommended that the ASTAR software be improved (as described in the Functional Description contained in the appendix of this document) before any further distribution of the prcgram takes place.

Prediction - Additional Titles

Evaluation

069 Hall, E.R., Rankin, W.C., & Aagard, J.A. (1976). Training effectiveness assessment: II Problems, concepts, and evaluation alternatives (TAEG Report No. 39). Orlando, FL: Training Analysis and Evaluation Group.

Examines specific problems affecting U.S. Navy training evaluation programs and discusses technical considerations relevant to evaluation and training effectiveness assessment. General procedures for assessing the effectiveness of Navy training courses are given, and methodological options for evaluation-data gathering are described and evaluated. Recommendations are made for improving training evaluation practice and for establishing a Training Effectiveness Assessment Center to assist in the planning and conduct of Navy training evaluations.

110 Maher, P.D. (1976-77). Evaluation of learning, performance, and productivity. Journal of Educational Technology Systems, 5(4), 341-353.

Presents a seminar paper which explored some of the requirements for understanding evaluation goals and techniques in designing learning systems. The author attempted to clarify what is meant by the term "applied learning technologist." The concept is approached in layman's terms, concentrating on the need for validating both the "learning" requirements and the corresponding "learning system" design. Suggested contents of a curriculum for an "applied learning technologist" certificate program are discussed. The results of a survey questionnaire are summarized.

104 Knerr, C.M., Downey, R.G., & Kessler, J.J. (1977). Training individuals in Army units: Comparative effectiveness of selected training extension course lessons and conventional methods. Catalog of Selected Documents in Psychology, 7(20).

107 Laabs, G.J., & Panell, R.C. (1977). Development of job-based diagnostic test in an individualized instruction program for boiler technicians. Proceedings of the Human Factors Society - 21st Annual Meeting.

A criterion-referenced test keyed to an individual, self-paced instruction program developed as part of a diagnostic testing/shipboard training system. The job-based test described hypothetical situations that were based on known job requirements. Under each such situation, questions were asked that required the demonstration of skills and knowledges that supported the job and were covered in the various modules of the instruction program. High face and content validity were ensured by using cards, charts, diagrams, and illustrations in presenting each job situation; and by having job experts write test items. Items were selected that best discriminated between graduates and nongraduates of a shore-based program using the same instruction. the cutoff score for the set of items pertaining to each module was determined from the performance of graduates of the shore-based program and applied to a cross-validation sample. Test scores from two administrations were used to estimate the reliability of the diagnostic decision making.

023 Carter, R.J. (1982). Methodologies for evaluating training products and processes. Proceedings of the Human Factors Society - 26th Annual Meeting, 258-262.

Methodologies for conducting training effectiveness evaluations (TEE) of ongoing Army training were detailed. The design process, consisting of a literature search and formative evaluations, was discussed. The developed TEE system was described.

112 Maitland, A.J. (1982). Training effectiveness analysis: Where the operator meets the equipment. Proceedings of the Human Factors Society - 26th Annual Meeting, 255-257.

A Training Effectiveness Analysis (TEA) was performed during the preparation for the final operation testing of the M1 (ABRAMS) Main Battle Tank. The results of the analysis of the training program for tank operators are discussed to illustrate the usefulness of TEA in the developmental process of Army training programs.

161 Sorenson, P.H., & Pennell, R. (1982). Technical training: development of instruction treatment alternatives (U.S. AFHRL TR 82-32). Brooks Air Force Base, TX: Air Force Human Resources Laboratory.

Provides guidelines for the development and evaluation of alternative instructional approaches that hold promise of improving instructional effectiveness, with emphasis on how to identify and test interactive relationships between individual differences among learners and instructional conditions or treatment. Problems of measurement that are basic to diagnosis and evaluation are discussed.

179 Witmer, B.G., & Kristiansen, D.M. (1982). The development and field trial of a system for evaluating the effectiveness and efficiency of a training program (ARI Research Report 1336). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Developed, tested, and refined a system to assist training managers or evaluators increasing the effectiveness of training programs. The Training Program Evaluation (TPE) system involves direct observation of training and testing rather than second-hand accounts by trainers or trainees. The TPE utilizes tests routinely given after each block of instruction. A major test of the system came when it was used to evaluate the effectiveness of the M1 tank transition training program and to suggest program improvements. The utility of the system was demonstrated. Several agencies have used the TPE to gather training effectiveness information that was subsequently used to improve the training programs. The training observation form, a training opinion questionnaire, TPE data collection forms and lesson learned during field trials of the TPE systems will help military managers avoid costly mistakes in conducting their own training program evaluations.

177 Wick, D.T., Ruffner, J.W., & Bickley, W.R. (1984). Conserving instructional training resources through use of the personalized system of instruction. Proceedings of the Human Factors Society - 28th Annual Meeting, 375-378.

Training managers in the U.S. Army face a continuing problem of meeting increasing training demands with limited instructional resources, particularly qualified training personnel. In most aviation unit flight training programs,

instructor pilot (IPs) serve a dual a role of academic lecturer and in-the-cockpit instructor. To reduce the amount of IP time required to administer training in a reserve aviator training program, a 19-day training program was developed that incorporates home study and features of the Personalized System of Instruction (PSI). Forty-seven aviators were trained using this program. Following one year of no training, 24 of the aviators returned for refresher training using the same program. The results indicate that the home study/PSI approach reduces on-site academic training time and virtually eliminates IP time on academic topics. The results also suggest that an academic training program based on PSI can be used successfully while conserving the scarce instruction resource of IP time.

064 Graham, S.E., Schlechter, T.M., & Goldberg, S.L. (1986). A preliminary evaluation of model maintenance training program for reserve component units (ARI Research Report 1421). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

16 U.S. Army soldiers participated in either a computer-based maintenance simulation training for M1 turret and hull mechanics or a no-training control procedure. Ss who had received the simulated troubleshooting training made fewer errors per period of time on the hands-on transfer task than did controls. The skills and knowledge developed in the courseware also generalized to a troubleshooting task not specifically trained.

005 Andrews, D.H., & Mohs, B. (1987). Key army decision maker concerns about training performance measurement and assessment. Proceedings of the Human Factors Society - 31st Annual Meeting, 1251-1255.

This study explored an area of Army training performance measurement and assessment (PMA) which has apparently not been examined. It provides an understanding about Army training PMA requirements and uses, and reveals a number of PMA issues which should be more closely examined in the future. The methodology adapted for the study combined elements of Policy Capturing Analysis with elements of Policy Implications Analysis and the Delphi Technique.

006 Baldwin, T.T., & Ford, J.K. (1988). Transfer of training: A review and directions for future research. Personnel Psychology, 41(1), 63-105.

Critiques the research on the transfer of training in which learned behavior is generalized to the job context and maintained over a period of time. The effects of training design, trainee, and work environment factors on conditions of transfer are discussed. Research gaps include the need (1) to test operations of training design and work-environment factors that have an impact on transfer and (2) to develop a framework for conducting research on the effects of trainee characteristics on transfer. Needed advancements in the conceptualization and operationalization of the criterion of transfer are also discussed.

169 Swezy, R.W., Perez, R.S., & Allen, J.A. (1988). Effects of instructional delivery system and training parameter manipulations on electromechanical maintenance performance. Human Factors, 30(6), 751-762.

Compared computer-assisted instructional (CAI)-based delivery systems with other training media to determine the extent to which instruction delivered via these methods affects performance on electromechanical maintenance tasks. Opportunity for hands-on practice, access to job aids, and instructional

delivery system parameters were manipulated: performance of 110 undergraduates (aged 17-43 years) was measured following training and again after 1 wk. Hands-on practice of the activity and access to job aids during training were found to significantly improve performance. However, no differences in performance of procedural maintenance tasks were found among Ss who were trained using CAI-based as opposed to other lower technology-based instructional delivery systems.

Evaluation - Additional Titles

Features (Training Management, Feedback, Fidelity)

159 Smode, A.F., & Hall, E.R. (1975). Translating information requirements into training device fidelity requirements. Proceedings of the Human Factors Society - 19th Annual Meeting.

The failure of training equipment to meet training needs is frequently attributed to poor engineering fidelity. Inaccurate or inadequate information requirements may be equally responsible for shortcomings in device design. Some observations and views on fidelity issues and on achieving fidelity requirements are offered.

042 Eggemeier, F.T. (1977). Two short-term techniques for gathering training device requirement information. Proceedings of the Human Factors Society - 21st Annual Meeting.

Two short-term questionnaire/interview techniques were used to specify device requirements for an aerial gunnery part-task trainer. The techniques differed in the degree of emphasis placed on eliciting expert pilot opinion regarding instructional capability and level of fidelity required in the trainer. Recommendations of pilots led to higher fidelity and more extensive simulator capability than did similar estimates derived bv training and engineering personnel from pilots' descriptions of the task in the operational environment. It is concluded that both methods are acceptable short-term techniques for initial identification of training requirements. However, long-term techniques appear to be optimal for making difficult decisions.

047 Finley, D.L., Strasel, H.C., Schendel, J.D., & Hawley, J.K. (1981). Training device operationalization readiness assessment capability (DORAC): The concept and its implementation. Proceedings of the Human Factors Society - 25th Annual Meeting, 416-420.

Army operational forces are required to report once a month on the readiness of their units for combat. The most difficult and subjective of the ratings going into this report is the one concerning personnel readiness. The problem is one of insufficient and outdated data concerning the current skill levels and training deficiencies of unit personnel. DORAC may provide a partial solution to this problem. This paper presents the concept and research issues; describes a cost-benefits method developed to provide training device proponents and developers a means to determine if and how to implement DORAC in the design and utilization of a specific device; describes the results of applying the method to exemplary training device design and usage options; and, presents findings regarding the extent to which one device represents a DORAC.

166 Strasel, H.C., Finley, D.L., & Hawley, J.K. (1982). Developing training devices with an effective capability for training management and readiness assessment. Proceedings of the Human Factors Society - 26th Annual Meeting, 840-844.

Army commanders and trainers need to know the current job performance levels of their troops. They need this information as the basis for making decisions about when and where to deploy units in battle, how much and where to allocate resources to training, what training readiness value to enter in the monthly Unit Status Report, and what specific training the soldiers should receive.

The problems are that currently few data are gathered, infrequently (e.g., SQT data every 2 years on a decreasing number of skill areas; (ARTEPs rarely!). The reasons for these problems are many. Principal among them are resource constraints (e.g., ammunition, ranges, personnel time) and measurement capability limitations (e.g., lack of instrumentation and inability to directly observe in field/actual equipment situations, and nonevaluative training devices). The results are incomplete data that are out of date, and older data are of dubious value due to personnel turbulence and skills decay.

029 Connelly, E.M. (1984). Instantaneous performance evaluation with feedback can improve training. Proceedings of the Human Factors Society - 28th Annual Meeting, 864-868.

Moment-to-Moment (MTM) performance measures derived from Summary Performance Measures, provide a near instantaneous evaluation of present performance according to how it impacts overall mission (i.e., summary) performance. MTM is a training tool permitting rapid feedback of performance information to the student as deviations from reference performance occur. While the sensitivity of MTM measures allow the rapid feedback at each moment of the task, experimental results suggest that such feedback should be carefully restricted to enhance training efficiency. Obviously, the feedback must use a mode (input channel) that is non-disruptive to the current task, but also the feedback should be modulated to focus on a portion of the total mission (presumably the part where present performance most seriously degrades overall mission performance). Further the trainee should be informed of that portion of the mission-keyed feedback.

This paper describes a research program in which MTM performance measure is used to generate training feedback signals where the feedback is keyed to the mission resulting in the desirable performance. But the time duration of feedback is limited to a fixed percentage of the total mission time. The impact of MTM feedback in improving training efficiency vs. feedback of only the total (summary) task performance score is presented along with a description of the method used to produce the MTM measure and the feedback modulation system.

171 Thomas, G.S., Kaplan, I.T. & Barber, H.F. (1984). Command and control training in the combined arms tactical training simulator (ARI Technical Report 615). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

The Army Training Battle Simulation System (ARTBASS) is being developed to succeed the Combined Arms Tactical Training Simulator (CATTS) as the U.S. Army's most combined group training system. The present research assessed the effects on command group performance of the CATTS/ARTBASS technology, supplemented by an Army Research Institute-developed diagnostic and feedback package. Five battalion command groups participated. Measures of performance included information flow during planning and execution, simulation battlefield outcomes, and ratings of critical tasks. All performance measures increased significantly from the first (pretest) to the fourth (posttest) exercise day. In a previous experiment using CATTS without added feedback, there was less improvement in performance. It is concluded that CATTS/ARTBASS training is effective when it includes detailed diagnostic feedback.

014 Brett, B.E., Chapman, W.A., & Hawley, J.K. (1986). Cost and information effectiveness analysis: An improved methodology (Volume II) (ARI Research Note 86-05). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

This report is the second of two volumes that present results of an effort to develop an improved methodology for the conduct of Cost and Information Effectiveness Analysis (CIEA). CIEA is a methodology for the evaluation of training device performance assessment capabilities (D-PACs). It is directed at the problem of determining when the worth of performance status information available from a D-PAC offsets the costs required to develop, operate, and maintain the capability. This report presents a case study which illustrates application of CIEA to evaluate a series of D-PAC alternatives that provide performance status information on the gunnery proficiency of crews for the Combat Engineer Vehicle (CEV). CEV gunnery D-PAC alternatives were developed by combining members of a set of interactive video gunnery trainers for the CEV with different types of live fire exercises. The case study describes activities conducted in the four phases of the CIEA of CEV gunnery D-PACs: exploration of the D-PAC concept for CEV gunnery, development of the D-PAC concept for CEV gunnery, definition of the CEV gunnery D-PAC alternatives, and evaluation of CEV gunnery D-PAC alternatives. Activities of the last phase culminate with specification of the most cost-effective CEV gunnery D-PAC alternative.

020 Carroll, R.J., & Dwyer, D.J. (1986). Maintenance training simulator instructor station and student station design specification. Proceedings of the Human Factors Society - 30th Annual Meeting, 131-135.

This paper discusses the methodology and results of a recent study conducted for the Naval Training Systems Center to develop a generic Prime Item Development Specification for maintenance training simulator (MTS) instructor and student stations (Carroll, et al., 1986). The approach taken was to develop a classification scheme for MTSs, develop a MTS instructor station/student station attribute taxonomy, conduct a commonality analysis of instructor/student station features among the different types of MTSs, and conduct a survey of MTSs to examine their characteristics and query instructors on their perception of the effectiveness, of instructor station/student station features. The survey results revealed that instructors gave high effectiveness ratings to most of the existing instructor station and student station features. The homogeneity of responses across MTS types indicates that instructor station requirements are a function of the instructional requirements associated with providing maintenance training via a training device, rather than being determined by MTS physical or functional characteristics. The study results were applied to the development of a model specification for MTS instructor station and student station design.

079 Hawley, J.K., Brett, B.E., & Chapman, W.A. (1986). Cost and information effectiveness analysis: An improved methodology (Volume 1) (ARI Research Note 86-04). Alexandria, VA: U.S. Army Research Institute for Behavioral and Social Sciences.

This report presents the results of an effort to develop an improved methodology for the conduct of Cost and Information Effectiveness Analysis (CIEA). CIEA is a methodology for the evaluation of training device performance assessment capabilities (D-PACs). It is directed at the problem of determining when the worth of performance status information available from a D-PAC offsets the costs required to develop, operate, and maintain the capability. Such a determination may be needed in order to specify

requirements for a D-PAC, or as a basis for deciding between two or more D-PAC design options intended to satisfy pre-specified requirements. Following the introductory section, a review of objective procedures for the assessment of information worth is presented. An objective method for information worth evaluation based upon the use of Combat Simulation Models (CSMs) is then explored in detail. The results of this evaluation based upon the use of Combat Simulation Models (CSMs) is then explored in detail. The results of this evaluation indicated that a CSM-based CIEA procedure, while technically feasible, is not practical. Section 3 of the report presents results from a series of formative tryouts of alternative multi-attribute utility measurement (MAUM) procedures for conduct of CIEA. Based upon these empirical results, recommendations for an improved MAUM-based CIEA methodology are made. The report continues with a detailed presentation of an improved methodology for the conduct of CIEA. In this improved methodology, a series of MAUM procedures are integrated into a standard cost-effectiveness framework. To illustrate the methodological description, an exemplary analysis on a set of hypothetical D-PAC alternatives is included. Finally, in Section 5, issues relevant to the improved methodology are discussed. Suggestions for future methodological development are also presented.

129 Polzella, D.J., & Hubbard, D.C. (1986). Utility and utilization of aircrew training device advanced instructional features. Proceedings of the Human Factors Society - 30th Annual Meeting, 139-143.

The utility and utilization of the Advanced Instructional Features (AIFs) capabilities of USAF Aircrew Training Device (ATDs) was explored by means of a survey of 534 Simulator Instructors from Air Training Command, Military Airlift Command, and Tactical Air Command training sites. The primary purpose of the survey was to provide a data base that could be used in defining the requirements for ATD procurements and in developing future ATD training programs. In general, the features that were rated highest in utility and utilization were those used for training management, variation of task difficulty/fidelity, and monitoring student performance. The level of AIF use was affected somewhat by hardware and/or software deficiencies; however, the presumed training value of an AIF was the most important determiner of its use.

056 Gibbons, S., & Singer, M.J. (1989). Evaluation of decision aids for training device design. Proceedings of the Human Factors Society - 33rd Annual Meeting, 1294.

Newly developed cost and training effectiveness models are being used by training developers to control costs and to ensure systematic training device design. The problem for the user is how to select the appropriate design aid. Unfortunately, there are no quick objective methods on which to base this selection. The selection decision for a particular application can be made based on three issues. The first issue is how the design aid addresses device instructional and fidelity features. The second issue is how the design aid formalizes the device design decision process. The third issue is to compare the systems on their ease of implementation. Two decision aids are analytically evaluated on their approach to training device design: OSBATS (Optimization of Simulation Based Training Systems), which is in prototype development, and ASTAR (Automated Simulator Test and Assessment Routine), which is ready to be fielded. These decision aids are based on differing theoretical approaches to formalizing training device design. OSBATS's taxonomy of fidelity features relates instructional features to individual tasks. OSBATS contains a trade-off function which uses historical cost and benefit values for individual features. It uses large amounts of detailed

information to drive its algorithms. ASTAR is a management tool which organizes the diverse interests of a design group to address design issues. ASTAR obtains judgments about instructional approach and device similarity for each training objective. ASTAR facilitates communication between members of a design team and insures a consensus on the issues.

157 Singer, M.J., & Willis, R.P. (1989). Data collection in support of the design of training devices. Proceedings of the Human Factors Society - 33rd Annual Meeting, 1295-1299.

A major problem in training device design is specifying the appropriate level of fidelity and required instructional features for learning. This research effort was designed to acquire detailed information about tasks and training device fidelity features. The standard method for developing information about task and fidelity relationships has been to conduct research into training methods using varying degrees of fidelity, or to extrapolate from evaluations of training programs based on newly developed training devices. The rotary-wing operations domain was selected as the basis for gathering detailed relationship data. A Training Device Fidelity analysis was conducted on many of the devices at the Army Aviation School at Ft. Rucker. A survey was then developed that crossed the tasks being trained on the AH-64 CWEPT (Cockpit, Weapons, and Emergency Procedures Trainer) and the UH-1 CPT (Cockpit Procedures Trainer) with the device characteristics present on those training devices. The survey was administered to instructors using the training devices. The survey responses were categorized, and the consensus results are being used in developing expert system rules. The conclusion drawn is that adequate data can be collected using surveys to generate experience-based (versus opinion-based or device evaluation-based) rules for determining necessary and sufficient fidelity aspects for training devices, where guidance is inferential and opinion-based, and where those devices are costly and/or need to be very effective.

TRAINING MEDIA

Features - Additional Titles

Media Selection

131 Reiser, R.A., & Gagne, R.M. (1982). Characteristics of media selection models. Review of Educational Research, 52, (4), 499-512.

Identifies and evaluates the learning effectiveness of the major features found in media selection models, with emphasis on the characteristics noted across models. Features discussed include the physical forms the models take, the ways in which they classify media, and the media selection factors they consider. Selection factors embodied in models affect media choices. Characteristics of learners, setting, and task are identified as factors to be given primary consideration in media selection.

106 Kribs, H.D., Simpson, A.C., & Mark, L.J. (1983). Automated instructional media selection (AIMS) (NAVTRAEQUIPCEN Technical Report 79-C-0104-1). Orlando, FL: Naval Training Equipment Center.

Developed and implemented the automated instructional media selection model to help reduce the cost and labor intensiveness of training program development by maximizing the use of pertinent information and automating the nonjudgmental, data manipulation tasks of the selection process. The user-definable aspect of the system allows for inclusions of any instructional characteristics. It also allows for better selection of hands-on training devices. Since the system is adaptable to any training situation, there is no bias toward cognitive, learning-center type media.

Media Selection - Additional Titles

Training Devices

173 Vestewig, R.E., & Eggemeier, F.T. (1979). Actual versus simulated equipment for aircraft maintenance training: Cost implications of the incremental versus the unique device. Proceedings of the Human Factors Society - 23rd Annual Meeting.

Life cycle cost estimates were developed for use of simulated test equipment versus actual test equipment in a maintenance training program of the type used for current advanced fighter aircraft. Previous life cycle cost comparisons had not explicitly considered the cost implications of procurement and support of a unique training device versus an incremental device. This effort included the unique versus the incremental device factor. Total estimated 15-year costs for simulated equipment trainers were significantly lower than comparable estimates for actual equipment trainers. The results indicate that the cost implications of a unique device versus an incremental device are important determinants of both acquisition and support cost estimates and should be considered fully in future life cycle costing efforts.

021 Carroll, R.J. (1983). Factors influencing the logistical support of maintenance training simulators: The development of a handbook. Proceedings of the Human Factors Society - 27th Annual Meeting, 1007-1011.

Experience with maintenance training simulators has revealed a number of unanticipated logistical support problems. In some cases, the logistical support costs (i.e., the costs of operating, maintaining, and updating) incurred during the life cycle of the simulator have been greater than expected and sometimes have exceeded the initial acquisition cost of the device. Many of these costs were incurred because the personnel responsible for the acquisition of simulators were not aware of the factors influencing the life cycle costs or were not aware of the problems that could occur in operating, maintaining, and updating simulators. In addition, they had no systematic procedure for evaluating the logistical support needs of the maintenance simulators they were purchasing. This report describes the development of a handbook that addresses these problems by identifying factors which impact the logistical support requirements of maintenance trainers/simulators throughout their life cycle and providing a guide to help predict and plan for the logistical support required of a given simulator.

080 Hays, R.T., & Singer, M.J. (1983). Research issues in training device design. Proceedings of the Human Factors Society - 27th Annual Meeting, 147-150.

The Army Research Institute (ARI) has an ongoing research program to systematically accumulate the data necessary to provide design guidance for the development of training simulators. As part of this research program, an extensive literature review was conducted. On the basis of this literature review, a series of research questions, which require empirical investigation was accumulated. This presentation is designed to bring these research issues to the largest possible audience. The goal of this paper is to sensitize researchers to the types of questions that have the highest payoff for the Army and the training community. The research questions are organized around a model of the Instructional Systems Development (ISD) process. Each ISD section is further subdivided into specific subareas where empirical research is needed.

Training Devices - Additional Titles

135 Rigney, J.W., & Towne, D.M. (1970). TASKTEACH: A method for computer-assisted performance training. Human Factors, 12, (3), 285-296.

Describes a method for using a computer timesharing system to assist the learning of serial tasks. The method is based on mediational theory. The current resurgence of interest in mediational theory in psychological research is noted, and parallels between experimental strategies and instructional strategies for evoking and manipulating mediating processes are pointed out. Categories of processes which mediate performance of serial tasks are described. Procedures for facilitating the learning of these processes are implemented by TASKTEACH. The program sustains S's performance of complex serial tasks by giving him variable amounts of support while helping him learn and organize the processes which mediate his performance of these tasks. The program generates output to S during the learning session by processing short lists and S's prior responses. The lists replace the conventional frame-by-frame description of an instructional sequence written in a computer-assisted instruction.

009 Blaiwes, A.S., & Rigney, J.W. (1974). A guide for developing performance-structure oriented computer-administered instruction: theory and research. Proceedings of the Human Factors Society - 18th Annual Meeting.

The work reported here had three main objectives with respect to computer-administered instruction (CAI), namely, to make CAI: (1) easier to develop, (2) higher in quality, (3) more widely appreciated and accepted. The approach taken toward these goals included two complementary kinds of efforts. One effort was directed toward designing guidelines and models of CAI which can assist training program developers in their efforts to implement CAI. Another effort was applied to the construction and field evaluation of a trainer which was based on descriptions and principles of CAI as contained in the guidelines and models. These efforts and some of their results are discussed here.

119 Moore, M.V., Nawrocki, L.H., & Simutis, Z.M. (1979). The instructional effectiveness of three levels of graphics displays for computer-assisted instruction (TP 359). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Ninety Army enlisted personnel studied one of three versions of a computer-assisted instruction (CAI) lesson on the psychophysiology of audition. The text of the lesson was identical for all versions; the type of graphics used in the lesson was different for each of the three groups. No control group was used. Graphics were either low (schematic representations and boxed alphanumerics), medium (line drawings), or high level (animations plus line drawings). After completing the lesson, all Ss were tested for retention of four knowledge categories: acquisition and use of principles, identification of structures, definitions and use of terminology, and memory of specific facts. Results indicate that the type of graphics used during the CAI lesson did not affect lesson completion time or final performance on the retention tests.

097 Kearsley, G.P., & Hillelsohn, M.J. (1982). Human factors considerations for computer-based training. Journal of Computer-Based Instruction, 8(4), 74-84.

Reviews the literature on human factors as it applies to computer-based training (CBT). The relationship between human factors and CBT research is illustrated by descriptions of studies dealing with six major aspects of the CBT interface: the administration of training, time management, instructional design/development, testing and development, student motivation, and hardware.

088 Jarvis, M.D. (1984). Computer-based training: lessons learned. Proceedings of the Human Factors Society - 28th Annual Meeting, 515-519.

Design and implementation of military maintenance training systems can draw upon a number of lessons learned from a review of literature and past experience of applications of computer-based training technology.

065 Gray, W.D., Pliske, D.B., & Psotka, J. (1985). Smart technology for training: Promise and current status (ARI Research Report 1412). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Discusses the Army Research Institute's Smart Technology for Training team, which has monitored research in cognitive and computer science to determine its applicability for Army training. Several long-term projects relate to the development and use of mental models of physical phenomena and devices. Applications of enhanced computer-assisted instruction to diagnostic and problem-solving training are described.

098 Kearsley, G., & Seidel, R.J. (1985). Automation in training and education. Human Factors, 27(1), 61-74.

Discusses the history of automated instruction, highlighting current applications, issues and problems, and future prospects. Current applications include traditional uses of computers for such tasks as testing, drills, tutorials, games, simulations, and student management, while new applications include embedded training, computer literacy, interactive video discs, and electronic lectures. Currently, the most important issue in automated instruction involves the time and costs associated with the development of courseware. Other important problems are the difficulty of implementing individualized instruction in organizations accustomed to classroom teaching, the scarcity of computer-literate educators, and the evaluation of courseware. Microcomputers have greatly accelerated the growth of computer-based instruction in all domains. Intelligent computer-assisted instruction programs, authoring systems, hand-held computers, speech processing, and telecommunication technologies (e.g., video text) are seen as shaping the future direction of automated instruction.

063 Gott, S.P., Bennett, W., & Gillet, A. (1986). Models of technical competence for intelligent tutoring systems. Journal of Computer-Based Instruction, 13(2), 43-46.

Analyzed the problem solving performance of 2 skill levels of apprentice electronics technicians (N=15) in a complex military workplace to derive the components of technical competence. Differences among individual apprentices were derived through a series of experiments that examined 3 elements of technical expertise- procedural contents consisting of the goal structures

that problem solvers impose on the problem space; conceptual knowledge, including explicit task structure, background, and contextual knowledge; and mental models that the problem solver has available to guide the initial problem representation. Results suggest that greater task success by the skilled performers was due to superior mental models and that conceptual knowledge was also a contributor to skilled performance. Implications for complex skill training are discussed.

070 Hamel, C.J. (1986). The CAI evaluation checklist: Guidelines for the design of computer-aided instruction. Proceedings of the Human Factors Society - 30th Annual Meeting, 136-138.

Human factors design guidelines for the development of computer-aided instruction are presented. The guidelines focus on the student-computer interaction and are organized around five human factors design principles for computer systems: brevity, consistency, flexibility, responsiveness, and compatibility.

076 Harris, S.D., & Owens, J.M. (1986). Some critical factors that limit the effectiveness of machine intelligence technology in military systems applications. Journal of Computer-Based Instruction, 13(2), 30-34.

Presents a critical assessment of issues in military systems applications of machine intelligence technology. Areas discussed include relevant research in artificial intelligence and cognitive science; computational theories of thinking; technological applications of research in memory organization, perception, and problem solving; the design of human-system interface; and the augmentation of human performance. Problems are noted with respect to coping with uncertainty, vagueness of performance criteria, and the effects of stress on human-machine dynamics.

132 Richardson, R.J., & Jackson, T.E. (1986). Developing the technology for intelligent maintenance advisors. Journal of Computer-Based Instruction, 13(2), 47-51.

Describes a demonstration study to develop an intelligent maintenance advisor (IMA), which is a computer-based device that (1) enables unskilled technicians to perform as if they were skilled, (2) tutors technicians who need further development in their technical skills, and (3) works cooperatively with skilled technicians to capture diagnostic insights for the benefit of peers/successors. For the experienced technician, the IMA provides interactive, cooperative, human-computer problem solving. Issues of knowledge representation and end-user interfaces are discussed.

146 Schlechter, T.M. (1986). An examination of the research evidence for computer-based instruction in military training (ARI Technical Report 722). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Reviews research on use of computer-based instruction (CBI) in U.S. military training. Over 150 papers and articles were examined, and interviews were conducted with professionals in the field of CBI. Major areas of focus include costs, learning achievements, individual differences, and student attitudes. It appears that the evidence is inconclusive with regard to advantages of CBI over other instructional media for reducing training time or life cycle costs, facilitating students' mastery of materials, accommodating individual learning differences, or motivating students. Problematic

methodologies were found throughout the CBI literature. Widespread implementation of CBI for all educational situations is not recommended.

Computer-Based Training (CBT) and Artificial Intelligence (AI) - Additional Titles

Other

031 Davies, I.K. (1984). Fitting the media key into instruction. Training and Development Journal, 38(12), 22-27.

Discusses the contribution of media to instructional design and argues that effectiveness rather than efficiency represents the primary goal of media usage. The design, development, and evaluation of instructional media require skill in diagnosis, decision making, and flexibility. The value of education and training in increasing employee reliability and improving performance is considered, and the importance of values in instructional technology is noted. Explicit and tacit dimensions of communication and knowledge are described, and the marketing of the media contribution to organizational health and effectiveness is discussed.

048 Finley, D.L., Alderman, I.N., Bogner, M.S., & Mitchell, N.B. (1984). Embedded training in the FOG-M (Fiber Optics Guided Missile). Proceedings of the Human Factors Society - 28th Annual Meeting, 527-528.

The Defense Science Board Summer Study of 1982 and the Army Science Board Summer Study of 1983 both recommended the incorporation of embedded training into operational systems as one solution to the shortage of unit resources providing realistic training to operational Army personnel. The Army Research Institute has initiated a research and development program to provide the means for the development of embedded training as a part of the systems acquisition process. One of the approaches in the program is the development of embedded training packages in exemplar systems selected as representative of types of systems, development stage and approach, and ET supportable system capabilities.

071 Hannaman, D.L., Druker, E.H., & Childs, E.L. (1985). Development of the functional requirements for simulation in combined arms training (SIMCAT) (ARI Research Report 1394). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Describes SIMCAT, a computer supported battle simulation that will be used for conducting research on how to train command, control, and communication skills in a classroom environment. SIMCAT will consist of six networked micro-computers (four trainee stations, and stations for the opposing force and the controller/ trainer). The system will use video disks and computer generated graphics to provide audiovisual cues, inherent in tactical situations, to all simulation participants. Voice synthesis and speech recognition technologies will permit trainees to control movement and firing using normal communication protocols.

068 Haiff, H.M., Hollan, J.D., & Hutchins, E.L. (1986). Cognitive science and military training. American Psychologist, 41(10), 1131-1139.

Discusses how the massive scale and diversity of training needs in the military render it an enterprise that offers extensive opportunity for the application of cognitive science. Training in maintenance, in tactics, and in piloting or control of aircraft present several issues of interest to cognitive scientists. Four recently developed military training systems illustrate the potential for cognitive science to improve military training. These systems include a family of memorization games based on semantic networks; a simulator for steam propulsion plants with a graphic, schematic student interface, a system for training in problems of relative motion that

provides explicit representations of spatial concepts and problem-solving procedures; and a method of building a new cognitive skill for air-intercept control based on principles for the development of automaticity. These systems illustrate the importance of making relevant knowledge concrete and explicit, of using problem-solving contexts for instruction in basic principles, and of careful management of information processing during learning.

Other - Additional Titles

FACTORS INFLUENCING TRAINING OUTCOMES

178 Williges, B.H., Williges, R.C., & Savage, R.E. (1979). Predicting optimal training group assignment. Proceeding of the Human Factors Society - 23rd Annual Meeting.

Multiple regression equations were used to assign 40 students to fixed-difficulty or adaptive training based upon the shorter predicted time-to-train score. In addition, 40 students were randomly assigned to the two training conditions, and 40 students were mismatched to training based upon the longer predicted time to train. Using predicted scores to match students to training alternatives resulted in a 47% savings in training time over random assignment and a 53% savings over mismatched assignment. The assignment effect was reliable at the 0.0001 level. Future research will examine different categories of predictors, additional training alternatives, and more complex training tasks.

113 Maitland, A.J. (1980). Using predictor equations to assess potential performance of armor enlistees (ARI Research Report 1240). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Examines research findings on predicting the performance of U.S. Army armor crewmen and shows how these findings may be applied in the current training program. Results of various methods of assigning groups of enlistees to training programs illustrate the effects of different decision rules on the end-product of training. With the method of prediction supplied in this review, the performance potential of groups of enlistees may be assessed from readily available test scores, and the result of assigning these individuals to different training programs may be estimated.

025 Cohen, A.D. (1982). The Hughes design analysis system and instructor workload in operational trainers. Proceedings of the Human Factors Society - 26th Annual Meeting, 364-368.

Computerized simulator trainers require varying degrees of instructor participation in training exercises and student performance evaluation. An estimation of instructor workload before the system has been fully developed is essential for an effective functional allocation of human and computer capabilities. One approach for estimating operator workload is simulation. The Hughes Design Analysis System (DAS) is an interactive and graphic simulation package. The present paper describes: (1) how DAS has been used for an instructor work load analysis, (2) the analysis method, (3) the results, and (4) the recommendations given to system designers.

105 Knerr, C.M. (1984). Armor procedural skills: Learning and retention (ARI Technical Report 621). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Investigated the learning and retention of a subset of 8 armor tasks selected to represent tasks that vary in length, complexity, and extent of practice in operational units. Two data collections were conducted. One collected performance data from 116 soldiers in operational units; the other utilized 471 soldiers attending One Station Unit Training (OSUT) in Armor Military Occupational Specialty. Ss in the operational unit sample had been out of OSUT entry training for up to 72 months. Ss in the OSUT sample participated in a series of task learning trials for two tasks followed by a retention trial approximately 4 weeks later. The operational unit Ss took a one-time

performance test on all 8 tasks. Results are consistent with previous skill retention research. Multiple regression analysis was used to predict the slopes of the retention function for each task for the combined sample. The prediction equation accounted for a large proportion of the variance when number of steps in the task, daily practice rate, and measures of complexity and interference were used as predictors of skill decay rate. Results of the OSUT, unit, and combined samples support a representation of the skill retention curve in which rapid decay occurs soon after training with little change in performance for samples tested later.

040 Dunbar, S.B., Mayekawa, S., & Novick, M.R. (1986). Simultaneous estimation of regression functions for Marine Corps technical training specialties. *Journal of Educational Statistics*, *11*(4), 275-292.

Considers the application of Bayesian techniques for simultaneous estimation to the specification of regression weights for selection tests used in various technical training courses in the Marine Corps. Results of a method for m-group regression suggest that a hypothesis of complete generalization of the predictor-criterion relationships across training courses in a given category would only be retained for a carefully selected subset of courses and not for all groups included in the analysis.

067 Hagman, J.D., & Hayes, J.F. (1986). *Cooperative learning: Effects of task, reward, and group size on individual achievement* (ARI Technical Report 704). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Investigated whether cooperative learning can effectively promote individual achievement, using 360 military trainees. Exp I compared the performance of 280 trainees after they had completed practical exercises under cooperative or individual learning. Results reveal that cooperative learning improved individual test scores when coupled with a group reward contingency, and significant benefits occurred once group size reached four members. Exp II employed 80 trainees to determine why group reward was necessary for obtaining enhanced individual achievement under cooperative learning. Two potential hypotheses were tested: (1) Group reward effects are caused by increased individual trainee motivation to learn resulting from group pressure to perform; and (2) group reward encourages group mates to share information, and this peer tutoring facilitates individual learning. Results support the peer tutoring hypothesis.

016 Brooks, J.E. (1987). *An instructor's guide for implementing cooperative learning in the equipment records and parts specialist course* (AD A191 660). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Cooperative learning is a new approach that is being implemented at the U.S. Army Quartermaster School for training Equipment Records and Parts Specialist (MOS 76C). This report describes the background, development, and application of an Instructor's Guide that was developed by the Army Research Institute (ARI) to familiarize course instructors with the specific procedures used in implementing the techniques. The guide itself is included in an appendix. The guide is divided into sections that are appropriate to the particular information needs of the three different instructor teams that teach the 76C course. It also contains general background information about the cooperative learning technique and the reasons for its implementation. although the main

purpose of the guide is to provide instructors with essential information, it may also be used as a model for developing similar guides for use in other courses that adopt the cooperative learning approach.

017 Brooks, J.E., Cormier, S.M., Dressel, J.D., Glaser, M., Knerr, B.W., Thorenson, R. (1987). Cooperative learning: A new approach for training equipment records and parts specialists (ARI Technical Report 760). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

This research investigated the usefulness of cooperative learning for promoting individual achievement in the Equipment Records and Parts Specialist Course (MOS 76C). cooperative learning students in four-member groups with group reward were compared to individual learning students on measures of course achievement, task completion speed, and study hall attendance. Student and instructor attitudes towards cooperative learning were also assessed. A trial implementation phase resulted in several procedural modifications, whereas the second phase was a controlled evaluation. The results showed that cooperative learning reduced academic recycling by about one half and had no effect on the test performance of most students. Students working in groups on practical exercises (PEs) made fewer errors than students working alone. Groups, however, often took longer to complete PE assignments. Normal training schedules were not disrupted by increased PE completion times or by increases in study hall attendance resulting from group rewards. Most students and instructors liked cooperative learning. It was concluded that cooperative learning is a feasible, low-cost approach that offers cost savings through reduced student recycling. Procedural modifications that may increase achievement benefits are noted, and future research directions are suggested.

083 Hogan, J., Arneson, S., & Salas, E. (1987). Individual differences in military training environments: Four areas of research (NTSC Tech Report 87-003). Orlando, FL: U.S. Naval Training Systems Center.

Addresses the variety of individual learning and ability differences that are brought to the training environment in terms of trainees cognitive strategies, trainees' noncognitive characteristics, and aptitude-performance interactions. Summarized findings are used to develop a decision model for a training program design that involves classification of training tasks, selection of personnel for training, and specification of instructional strategies for optimal learning. Task types include the realistic, investigative, artistic, social, enterprising, and conventional. Personality factors include "intelligence", adjustment, prudence, ambition, sociability, and likeability.

093 Jones, M.B., Kennedy, R.S., Kuntz, L.A., & Baltzley, D.R. (1987). Isoperformance: Trading off selection, training, and equipment variations to maintain the same level of systems performance. Proceedings of the Human Factors Society - 31st Annual Meeting, 634-637.

121 Mumford, M.D., Harding, F.D., Fleishman, E.A., & Weeks, J.L. (1987). An empirical system for assessing the impact of aptitude requirement adjustments on Air Force initial skills training (U.S. AFHRL Technical Report 86-19). San Antonio, TX: U.S. Air Force Human Resources Laboratory.

Developed a decision support system for Air Force personnel and training management. Measures of student input, course content, and training outcome were obtained for 39 initial skills courses and 5,000 trainees. A

hypothetical model of initial skills training is presented. When cross-validated using 9 additional training courses and 1,000 trainees, the model yielded predicted training outcomes that were consistent with actual training outcomes.

122 Mumford, M.D., Weeks, J.L., Harding, F.D., & Fleishman, E.A. (1988). Relations between student characteristics, course content, and training outcomes: An integrative modeling effort. Journal of Applied Psychology, 73(3), 443-456.

We have attempted to formulate a general multivariate model describing the relationships among individual attributes, course-content variables, and performance indexes in Air Force training programs. A series of interviews with course instructors and training managers led to the identification of six student-characteristics, 16 course-content, and seven training-performance variables held to be important descriptors of the training process, regardless of the particular program under consideration. Measures of these variables were then obtained in 39 training courses containing 5,078 students. The relationships observed among these variables were used to develop a hypothetical model that was submitted to formal structural analysis. This structural model was cross-validated on a sample of 9 additional courses containing 890 students. In cross-validation, the model predicted training performance criteria with sufficient accuracy to be considered a valid descriptor of the technical training process.

051 Fleishman, E.A., & Mumford, M.D. (1989). Individual attributes and training performance. In I.L. Goldstein and Associates (Ed.), Training and development in organizations (pp. 183-255). San Francisco, CA: Jossey-Bass Publishers.

Reviews literature on individual differences as expressed in abilities, skills, and knowledges and the impact of these differences among people on training outcomes. Stresses the importance of learners' characteristics on learning and training of such variables as aptitudes, reading level, academic motivation, educational level, educational preparation, and age. Discusses at length the Ability Requirements Taxonomy system with 50 ability categories. Describes how to link abilities and job/task requirements in training, skill acquisition, training system design, and training research.

Factors Influencing Training Outcomes - Additional Titles

COSTING AND RESOURCING

Cost and Resource Estimation

043 Eggemeier, F.T. & Klein, G.A. (1978). Life cycle costing of simulated vs. actual equipment for intermediate maintenance training. Proceedings of the Human Factors Society - 22nd Annual Meeting.

Life cycle cost estimates of training equipment for F-16 Avionics Intermediate Station personnel were developed. The major purpose was to compare the cost of intermediate level maintenance training when conducted on simulated versus actual avionics test equipment. This was the initial phase of a planned two-part effort. The analysis was therefore limited to estimates of training device acquisition and maintenance costs. Total estimated fifteen year costs for simulated equipment trainers were approximately 50% less than comparable estimates for actual equipment trainers.

117 McCullough, J.M. (1984). To measure a vacuum. Training and Development Journal, 38(6), 68-70.

Describes the Deficiency Analysis Review Technique (DART), a method for justifying training needs and quantifying results of training. DART may cause managers to become more receptive to training because it quantifies the cost of not doing the training. The system involves systematically identifying and measuring deficient operations and unnecessary expenses, which then become the target of formal employee training. The steps in DART include problem identification, goal development, methodology development, cost/benefit analysis, documentation, course development, and course implementation.

Costing and Resourcing

Cost and Resource Estimation - Additional Titles

Factors Affecting Cost

026 Cohen, E. (1973). Training time as a selection criterion for entrants to individualized training programs. Psychological Reports, 32(3, Pt 1), 715-718.

Considers that the criterion for selection of entrants to training and educational programs is almost always success in the training program itself; occasionally the criterion is performance on the job for which the training program is prerequisite. The advent of individualized training programs, in which each trainee proceeds at a rate determined by his own learning speed rather than in "lock step" with the rest of his class, opens the possibility of selecting the faster learners and thus effecting substantial economies. Some of the implications of the "select for speed of learning" approach are discussed.

Factors Affecting Cost - Additional Titles

MISCELLANEOUS

058 Goclowski, J.C., King, G.F., Ronco, P.G., & Askren, W.B. (1978). Integration and application of human resource technologies in weapon system design: Consolidated data base functional specification (U.S. AFHRL Technical Report, No. 78-6(3)). San Antonio, TX: U.S. Air Force Human Resources Laboratory.

Describes the consolidated data base (CDB) required to support the application of the coordinated human resource technology (CHRT) on a weapon system acquisition program. The major categories of data stored in the CDB relate to reliability, maintainability, maintenance manpower, operations manpower, training, and job guides for both maintenance and operations, and system ownership costs. The CDB may also be used for operational and support planning after deployment. As developed for application, the CDB is unique to each weapon system. It expands in detail with time as the weapon system acquisition cycle progresses. The CDB is dynamic in nature representing alternatives being considered as well as baseline approaches. It has, therefore, been designed for frequent update and expansion.

061 Goldstein, I.L. (1978). A systems approach to studying organizations: selection, training, performance. Proceedings of the Human Factors Society - 22nd Annual Meeting.

This presentation explores the idea that training analysts have not fully utilized the rich source of data which can stem from the examination of training programs. Several approaches including individual difference methodology, trainee expectations and training process measures are discussed.

073 Hanson, V.L., & Purifoy, G.R. (1979). TSM guide to training development and acquisition for major systems. Catalog of Selected Documents in Psychology, 9, 99-100.

170 Swezy, R.W. (1979). An application of a multi-attribute utilities model to training analysis. Human Factors, 21(2), 183-189.

The multi-attribute utilities model of W. Edwards et al. (1975) Bayesian-oriented decision-making paradigm, was applied to a decision-making problem in a military training analysis situation. The model is compared to a second simple judgment analysis model using the same input data.

053 Freda, J.S. (1980). Army training technology transfer: A systems model (ARI Research Report 1241). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Innovations in training technology must be transferred from the researcher to the user to be effective. This system concept paper presents a framework for the establishment of an Army training technology transfer program, as well as suggestions to improve the acceptance and use of training research products.

Training technology transfer is defined as the process by which research results become implements of useful change in operational training. The user can be civilian or military, functionally involved at levels from high-level review to the trainer in the field. The systems model developed here uses a linear approach to describe the four steps of technology transfer in the Army: analysis of requirements; research, development, test, and evaluation of solutions; dissemination of findings; and institutionalization. Within these

steps, specific issues include assessment of military needs, consideration of the appropriateness of current RDT&E funding, user acceptance of new products, and the transition from innovation to policy, as well as prediction methodology and recommendations for ongoing monitoring, evaluation, and feedback. Recurring throughout the transfer process are issues of sponsorship and the self-renewal capability of the research product.

A bibliography on training transfer is organized in terms of specific activities within the model.

062 Goldstein, I.L. (1980). Training in work organizations. Annual Review of Psychology, 31, 229-272.

Examines issues concerning systematic modes of instruction designed to produce environments that shape behavior to satisfy stated objectives. The literature and state of the field are reviewed in the areas of (a) general systems philosophy (needs assessment, the instructional process, and evaluation); (b) approaches to training issues (developmental psychology aspects; training for hard-core unemployed, women, and the aged; individual differences; and fair employment practices); (c) training for various functions (police, management); and (d) training methods (sensitivity training, simulations, and computer-assisted and programmed instruction).

094 Jones, M.B. (1981). Convergence-divergence with extended practice: Three applications (NBDL-81R010). New Orleans, LA: U.S. Naval Biodynamics Laboratory.

The author and colleagues (1980) introduced the concept of "convergence/divergence with practice" to indicate changes in the correlations between a task and an external measure over time. The present paper develops this concept in 3 settings: differential retention over long periods of no practice, personnel selection and classification, and the identification of latent factors. Military research projects using video games or code substitution tasks are reviewed to demonstrate that the correlation between a S's terminal level of performance in practice and retraining should increase with the number of retraining trials. Implications are discussed for personnel selection in cases in which the criterion develops in a series of stages or phases and/or factor-analytic attempts to identify abilities.

095 Jones, M.B., Kennedy, R.S., & Bittner, A.C. (1981). Video games and convergence or divergence with practice (NBDL-81R010, 1-5). New Orleans, LA: U.S. Naval Biodynamics Laboratory.

Discusses the use of video games as psychological tests of skill acquisition and learning and their fulfillment of the requirements of stabilization and task definition in performance testing. Cross-correlational data from 13 U.S. Navy enlisted personnel on air combat maneuvering simulation and a commercial video game reveal that performance skills on these 2 measures systematically increased over 15-day trials. Application of video games to pilot selection and training is discussed.

133 Rigg, K.E., Gray, B.B., & Tillman, B.W. (1982). Estimating skill retention from initial training. Proceedings of the Human Factors Society - 26th Annual Meeting, 263-265.

Performance of a procedural skill is known to decay in the absence of practice; for many tasks significant decay is observed over periods as short as a few weeks. This decay in performance has been observed in such diverse groups as astronauts, chemical operators and Army riflemen. Unsurprisingly, many Army basic tasks are forgotten in the period between basic training and unit assignment. This report presents the findings of a research effort to apply a mathematical training model developed by McFann-Gray & Associates, Inc. (MGA), to Army basic training: (1) to describe initial training; (2) to estimate end-of-course performance; and (3) to estimate the level of field performance after a retention interval without practice.

165 Sticht, T.G. (1982). Basic skills in defense (HumRRO Professional Paper, PP 3-82). Alexandria, VA: Human Resources Research Organization.

A literature review indicates that a debate about basic skills training for recruited military personnel has been unresolved for 200 years. Those against basic skills training cite costs, ineffectiveness, and undesirable performance. Those for basic skills training cite demographics, wartime needs, and equality of performance among highly literate and less literate personnel. Selection, classification, training, and job performance studies have yielded results that support both sides. Congress has directed that high school diploma programs be available during off-duty hours and all services require some education credentials for noncommissioned officer rank. Experience with basic skills programs in the various services has been generally favorable with job-oriented basic skills training demonstrating the positive effect of literacy on job performance. It is suggested that if the current trend toward job- and career-oriented basic skills education continues, the debate will be resolved.

050 Fisk, A.D., Scerbo, M.W., & Schneider, W. (1983). Issues in training for skilled performance. Proceedings of the Human Factors Society - 27th Annual Meeting, 392-396.

Four fallacies concerning training for skilled performance that are often implicitly assumed in training programs are discussed. These fallacies are: (1) Practice makes perfect; (2) Training of the total skill is optimum; (3) the goal of training is to produce accurate performance; and (4) skill training is intrinsically enjoyable. Automatic/controlled processing theory, which emphasizes how training may be done to avoid these fallacies, is briefly discussed. Finally, 11 training guidelines are provided for the optimization of skill training.

074 Harmon, J. (1984). Three years of evaluation of the Army's basic skills education program (ARI Research Report 1380). Alexandria, VA: U.S. Army Institute for the Behavioral and Social Sciences.

Summarizes 3 years of evaluation research on the U.S. Army's Basic Skills Education Program, which provides enabling skills in literacy, language, arithmetic, computation, and speaking. Analyses of standard, pilot, and revised programs as well as programs under development are described. Overall findings reveal that all programs tend to move participants in the direction of Army goals, although a substantial number of soldiers fail to meet program

criteria. Factors that may dilute program effectiveness include teachers' lack of specialized training, the wide range of skill levels within classes, and personnel turbulence.

136 Risser, D.T., & Berger, P. (1984). Army HARDMAN: Its origin, evaluation, implementation to date. Proceedings of the Human Factors Society - 28th Annual Meeting, 716-720.

The HARDMAN Comparability Methodology was developed by the Navy to estimate human resource requirements during the early phases of weapon system development. The Army has modified the system to support its own needs in this area. Four real system applications in the Army and an evaluation by the Jet Propulsion Laboratory indicated that it is useful, usable, and reasonably credible, and provides a near-term solution to the Army's needs. An Army Guide is under development.

181 Zimmerman, W., Butler, R., Gray, V., & Rosenberg, L. (1984). Evaluation of the HARDMAN (hardware vs. manpower) comparability methodology (ARI Technical Report 646). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Evaluated the U.S. Army's HARDMAN methodology for projecting manpower, personnel, and training (MPT) requirements to support new acquisitions. Tests included a general examination of the basic reasonableness of the technique; a reliability measure of how well other trained individuals, given the same data inputs, can derive the same answers as an already-completed test case; a qualitative accuracy check based on conversations with individuals who have already applied the same, or a similar, methodology; and a measure of how accurately the methodology must predict the real world. The evaluation reveals that the methodology conforms fairly well with both the Army's MPT users' needs and other accepted manpower modeling techniques. Audits of 3 completed HARDMAN applications and the reliability study reveal a need to consolidate select judgmental portions of the methodology and to improve those aspects of the technique used for making MPT support and budget decisions. Results suggest that the manpower life-cycle cost component is only marginally sensitive to changes in other related cost variables.

147 Schneider, W. (1985). Training high-performance skills: Fallacies and guidelines. Human Factors, 27(3), 285-300.

Argues that training programs for developing high-performance skills (HPSs) are often based on assumptions that may be appropriate for simple skills. These assumptions can be fallacious when extended to HPSs. Six fallacies of training are described, and empirical characteristics of HPS acquisition (e.g., long acquisition periods, heterogeneity of component learning, developing of inappropriate strategies) are reviewed. A tentative set of guidelines for the acquisition of HPSs is described.

019 Carnevale, A.P. (1986). The learning enterprise. Training and Development Journal, 40(1), 18-26.

Discusses the size, scope, and influence of present-day training and development. It is suggested that most American employees learn what they need to know to do their jobs in schools and on the job, formally and informally. School tends to be most important for managers, professionals, technical and sales employees, and people in publicly regulated jobs. Most formal training in the workplace concentrates in the 25-44-year-old age group

and among white-collar managers, professionals, and clericals. Informal training is most important in blue-collar jobs. Research indicates that the split between behavioral and cognitive training and development shows that roughly two-thirds of all formal training and development is cognitive and that one-third is behavioral. Workplace training inside and out, costs and benefits of workplace learning, and the growth and decline in the training and development function in companies are discussed. Tables are included that represent trends in training and development, such as sources of training and retraining by occupational groups, employee training by industry, changes in employee participation in training and use of outside training resources, and demand for trainers.

084 Holt, V.E. (1987). Issues in psychological research and application in transfer of training (ARI Research Note 87-65). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

This research note is a collection of papers and summary recommendations resulting from a two-day workshop focused on training transfer. Supported by the Army Research Institute, the workshop featured presentations by academic, non-academic, and military laboratory scientists on psychological research and applications related to transfer of training. Among the specific topics dealt with are: the development of cognitive simulation models, skills development methods, the need for intelligent job aids, cognitive task analysis, and methods for measuring job performance. Recommendations for further research and applications are provided.

153 Sicilia, G.T. (1988). Developing a training data architecture that ties it all together. Proceedings of the Human Factors Society - 32nd Annual Meeting, 1198-1201.

Everyone involved in quantifying the human part of the defense equation has long been frustrated by lack of consistent, "reproducible" and comprehensive data. This void is especially evident in the training and performance data area. The Defense Training and Performance Data Center (TPDC) was established to help redress this problem.

041 Duncan, C.S., & Greenston, P.M. (1988). Occupation data base planning and design. Proceedings of the Human Factors Society - 32nd Annual Meeting, 1202-1206.

The Occupation Data Base under development at TPDC consists of three files. The first file describes military occupations, providing information about the attributes of the occupation. It addresses the question: what does the occupation look like? The second file describes occupations from a "demographic" perspective, or more simply put, answers the question: who are the people performing the job? It provides a statistical profile (current and historical) of the characteristics, experience, and behavior of the people serving in each military occupation. The third file provides a data file on training programs, resources, methods and media as these elements relate to military occupations. All occupations within the enlisted, warrant officer, and officer communities are covered in each service, both active and reserve components. These three files are being built from current and historical data and will be updated regularly, thereby providing a comparative perspective with which senior service planners can make informed decisions on defense training issues.

037 Driskell, J.E., & Olmstead, B. (1989). Psychology and the military: Research applications and trends. American Psychologist, 44(1), 43-54.

Perhaps no other institution has been as inextricably linked with the growth and development of psychology as the military. This symbiotic relationship, born of the expediency of World War I, rests on two roles: (a) the military as a test-bed or applied laboratory for the examination of psychological processes, and (b) the military as an impetus to initiate and direct research and innovation in psychology. In this article, we examine three areas of research that in historical perspective have most prospered from this relationship: selection and classification, training, and human factors. We address topics that hold promise for future collaboration and describe how the military manages research and development. Finally, to assist those interested in research opportunities with the military, we profile the primary behavioral science research organization within the Department of Defense.

081 Herlihy, D., Bondaruk, J., Nicholas, G., Guptill, R., Park, J. (1990). Hardware versus manpower compatibility methodology. Volume I. Overview and manager's guide. Wilmington, MA: Dynamics Research Corporation.

The Army Hardware vs. Manpower (HARDMAN) Comparability Methodology (HCM) is a six-step process for determining a weapon system's manpower, personnel, and training (MPT) requirements. It provides a structured approach for early MPT estimation based on comparability analysis, an analytic system that uses knowledge about similar existing systems and technological growth trends to project the MPT requirements of proposed new systems. The HCM's six interrelated steps are systems analysis, manpower requirements analysis, personnel pipeline analysis, training resource requirements analysis, impact analysis, and trade-off analysis. The HCM has been successfully applied to a range of weapons systems, including air, armor, artillery, infantry, air defense, command and control, and intelligence systems. The product improvement program for HCM made major revisions to the existing HCM guide. The scope has been expanded to include several new areas; existing procedures have been revised, refined, and clarified; and the entire guide has been rewritten to achieve greater charity, consistency, and completeness. This volume addresses the planning and conducting of an HCM analysis. Procedures are provided for determining the analysis scope and estimating the resources required for the analysis. Preparation of the quality assurance plan and establishment of the consolidated database are explained. The relationship between HCM results and various Army MPT documents is also discussed.

Miscellaneous - Additional Titles

APPENDIX

AUTHOR INDEX

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